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THE ASSOCIATION was organized in Boston, Mass., on June 21, 1882, with the object of providing its members with means of social intercourse and for the exchange of knowledge pertaining to the construction and management of water works. From an original membership of only TWENTY-SEVEN, its growth has prospered until now it includes the names of over **900** men. Its membership is divided into two principal classes, viz.: MEMBERS and ASSOCIATES. Members are divided into two classes, viz.: RESIDENT and NON-RESIDENT, — the former comprising those residing within the limits of New England, while the latter class includes those residing elsewhere. The INITIATION fee for the former class is FIVE dollars; for the latter, THREE dollars. The annual dues for both classes of Active membership are THREE dollars. Associate membership is open to firms or agents of firms engaged in dealing in water works supplies. The initiation fee for Associate membership is TEN dollars, and the annual dues FIFTEEN dollars. This Association has six regular meetings each year, all of which, except the annual convention in September, are held at Boston.

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ORGANIZED 1882.

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This Association, as a body, is not responsible for the statements or opinions of any of its members.

THE GREENFIELD WATER WORKS.

BY GEORGE F. MERRILL, SUPERINTENDENT OF WATER WORKS.

[*Read December 9, 1914.*]

At Greenfield, Mass., the water works are owned and operated by a fire district, which contains about ninety per cent. of the valuation of the town, and supplies water to the whole town, with the exception of the farming district.

The water supply is taken from the watershed of Glen Brook in the town of Leyden, by gravity, supplemented by an auxiliary pumping station, taking a supply from a well located in the valley of the Green River, near the river.

The original works, built in 1872, are composed of a reservoir on Glen Brook, of about 24 000 000 gal. storage capacity, situated 225 ft. higher than the main street, and located about five miles from the center of the town. At the time of the construction of the system, cast-iron pipe was very high, compared with the present market, and the mistake was made, which was a common one in our New England towns and cities at that time, of putting in mains that were too small.

As the town grew, and its demands for water and fire protection became greater, it became necessary in 1885 to lay an additional 14-in. main to the reservoir, to give better protection in case of fire. This, together with some essential reinforcements of the pipes in the built-up section of the town, was constructed at a cost of about $75 000. The next improvement, other than the regular extension of the mains within the town, was made in

1894. At this time it was found that the 5.5. sq. miles of area which supplies the Glen reservoirs would not in the drought years, with the available storage, yield sufficient water to supply the town. After considerable investigation by committees it was decided to install an auxiliary pumping station on Green River, taking raw water from the stream, and pumping it into the mains through a 10-in. force main half a mile long, where it connected with the existing main pipes from the reservoir to the town. The equipment then installed consisted of a locomotive type boiler, and a 16 by 10 by 10 steam pump, with which it was possible to maintain a supply of water for the town when the gravity supply failed, although at a very excessive cost for pumping. This excessive cost of pumping (about $40 per million gallons) added considerable to the cost of maintenance, but did not amount to a very serious expense until 1909, when an increased amount of pumping became necessary.

About ten years after this original pumping station was installed, the growth of the town made it necessary to obtain a greater supply to carry the town through the dry seasons. The capacity of the pump was insufficient, and the location was such that, in order to get sufficient water, it was necessary to build temporary dams in Green River to raise the water a few feet, so that it would flow into the pump pit. As the river bed at this point was composed of coarse gravel, a large portion of the flow of the stream was lost through seepage; there were also several small water powers located about five miles further up the stream which held back the flow at times, so that there was not enough water flowing to supply the pump.

At this time it was voted to build a storage reservoir above the existing reservoir on Glen Brook, which was expected to store sufficient water to tide over the dry periods. This reservoir was completed in 1906, at a cost of about $85 000. The dam was designed by E. A. Ellsworth, of Holyoke, who worked in connection with Chas. J. Day, a civil engineer, who was at that time chairman of the board of water commissioners. The storage capacity is 44 000 000 gal. This dam raises the water about 45 ft., but, as the reservoir is located in a narrow valley, and the watershed is abrupt, the result is that a comparatively small amount of stor-

age is obtained. A large item of the cost of the reservoir was the construction of the foundation. A pocket was found in the bed of the stream, which had to be excavated to a point 42 ft. below the water level to obtain rock foundation. The whole structure rests on ledge, and is built of 1 : 3 : 5 concrete with large stone imbedded. From the upper reservoir to the lower, and connected below the lower, a 30-in. cast-iron pipe is laid. The gate arrangement is such that supply may be drawn from either reservoir separately, or water discharged from the upper to the lower. The 30-in. pipe is laid along the easterly shore of the lower reservoir, and has been tapped for 2½-in. fire-hose connections at intervals of about 100 ft. along the whole length of the reservoir. During the spring, when the lower reservoir is being cleaned, we use fire hose for flushing out the silt and mud, and find this method very economical and thorough.

The fire department at Greenfield is operated by the fire district, and there are no steam fire engines, all the fire service being obtained from hydrants. The length and size of the main pipes from the reservoir to the town are such that a large volume of water at reasonably good pressure cannot be delivered. About seven years ago, a short time after coming to Greenfield, I became aware of this condition, and hydrant tests showed that, in the center of the town, not over four efficient hydrant streams were available at the same time.

At this time I recommended, as a remedy, the construction of a reservoir on Rocky Mountain, about a mile from the town, to be supplied by the present gravity supply, through a 24-in. pipe.

In May, 1909, there was a very serious fire, which demonstrated clearly the lack of water for fire service. Very shortly afterwards a meeting of the voters was held, at which an appropriation of $75 000 was made to build a covered concrete reservoir on Rocky Mountain with the necessary pipe connections, and Mr. Wm. S. Johnson of Boston was employed to prepare the plans. The contract for its construction was awarded to Daniel O'Connell's Sons, of Holyoke. The work of installation of pipe valves and laying about 6 000 ft. of 24-in. pipe to the center of the town was done by the water department.

The reservoir is built wholly on ledge, a portion of it being ex-

cavated from the trap rock which occurs on the summit, obtaining in this way sufficient material for the embankment. A concrete floor, 6 in. thick, was laid in alternate sections after the walls were completed. The roof is of groined arch construction, supported by 24 in. square concrete columns, spaced 17 ft. on center. The reservoir has a capacity of 2 000 000 gal. and is supplied through a 24-in. cast-iron main which is laid to the center of the town, and which also protects the main business portion of the town. In operation, this reservoir has a standpipe effect, supplying at all times enough water for fire service. Water flows in during the night to take the place of that which is used during the day. The control of the water level in the reservoir is entirely automatic, and the same 24-in. pipe through which the water supply comes is used for water to return to the town. By the use of two check-valves and a float valve, the water is shut off automatically when the reservoir becomes full, and in case of a slight drop in pressure down-town, a check-valve in the 24-in. outlet pipe opens and water from the reservoir enters the system.

Although the contract to the reservoir was started in 1909, the addition to the system was not completed until the following summer, at which time a hydrant test was made, which illustrates the gain in fire service obtained.

The first part of the test was made with the Rocky Mountain reservoir shut off, and represents the conditions as they were before this addition to the water system. This test was as follows:

With the hydrant pressure at 97 lb. the normal ten fire streams were connected, using 150-ft. lines of $2\frac{1}{2}$-in. hose with $1\frac{1}{8}$-in. nozzles. With these streams, the pressure dropped to 27 lb. With six of the above streams, the pressure was maintained at 39 lb.

The Rocky Mountain reservoir was then turned on, the pressure standing at 87 lb., which is normal from this source. With 16 streams the pressure dropped to $81\frac{1}{2}$ lb. and then four more streams were added, and a wagon-pipe with three-way siamese connection, 50-ft. lines of $2\frac{1}{2}$-in. hose and $1\frac{3}{8}$-in. nozzle. With all the above streams, which were connected with 150-ft. lines of $2\frac{1}{2}$-in. hose and $1\frac{1}{8}$-in. nozzles, excepting the wagon-pipe, which had $1\frac{3}{8}$-in. nozzle, the pressure was maintained at $81\frac{1}{2}$ lb.

The streams with $1\frac{1}{8}$-in. nozzles should discharge, under the

above conditions, about 266 gal. per minute, which indicates that the total discharge with 20 streams and wagon-pipe was about 6 000 gal. of water per minute.

The streams with $1\frac{1}{8}$-in. nozzles, when all were in service at the same time, were sufficient to give effective service at a height of 80 ft.

The wagon-pipe as connected will furnish an effective stream 120 ft. in height.

The upper reservoir on Glen Brook did not accomplish the result for which it was intended, as it lacked sufficient storage. In fact, the first year it was used it was necessary to pump water from Green River at the old pumping station. The question of a further additional water supply was given very careful study before anything was done regarding construction. Investigation of a possible ground-water supply was made over a large area. The first work in this connection was done in the valley of the Barton Brook, lying easterly of the Glen Brook watershed. In this valley we obtained some very encouraging results from flowing wells, and located a good supply of water; but analyses showed it to be unfit for use on account of an excessive amount of iron and chlorine. Further investigation on the same stream up the valley developed a supply of good water, but at such a distance from the town that the cost of development would be quite large; and, as the watershed was a comparatively small one (five or six square miles), it seemed better to depend on the larger Green River watershed, if suitable locations could be found. Therefore test wells were driven, making a very thorough exploration of the river valley from a point about half a mile northerly of Greenfield to the present new pumping station which was built last year. At this point the river valley widens out and, leaving the narrow mountain gorge, enters a more level plain. Test wells driven at this location showed a large bed of gravel containing sharp sand of about the quality of filter sand. The gravel, however, contained many large-sized stones, and some bowlders.

In connection with further investigation of additional water supply, surveys were made up the valley of the Green River to determine the cost of obtaining a gravity supply; also surveys were made above the existing reservoirs on Glen Brook watershed

for a storage reservoir. On the Glen Brook watershed a favorable dam-site was located where storage could be obtained at a cost of about $300 per million gallons. The capacity of a reservoir on this site would be about 400 000 000 gal. with a sufficient watershed to easily fill it in the driest years. When we compare the cost of storage at this proposed site ($300 per million gallons) with the cost of storage at the present upper reservoir (about $2 000 per million gallons) it was evident that proper engineering investigation was not made before the upper reservoir was constructed.

On the Green River watershed, surveys indicated that a gravity supply could be obtained, but it was necessary to construct about 11 miles of pipe line to bring it into town. Green River has a watershed of about 50 sq. miles above our new pumping station. Its source is in the state of Vermont. Our taking would occur at a point so near the Vermont line that a large portion of the watershed would be over the line, where it would be difficult for us to exercise sanitary control. A gravity supply from Green River was not considered the best for our present needs, because of the expense — estimated cost being about half a million dollars, our present needs requiring slightly over 100 000 000 gal. per year to carry us over the dry period, as shown by our pumping records.

The ground water supply which was completed last year was decided upon because of the comparatively small outlay, and the better, cleaner supply of water available. All the work of construction was done by the water department.

Some of the features connected with the new supply were the construction of a large well, and a filter-bed which was built in the gravel about 100 ft. from the well. A low dam was constructed on Green River, about 800 ft. northerly of the well, which raised the water 8 ft., sufficiently to flow on to the filter bed. The pumping station is a brick building with concrete foundations, in which is installed an electric driven pump. There was also laid a 16-in. force main about 2 600 ft. long, which is connected to the existing main from the reservoir to the town.

The construction of the well was done under unusual conditions, and, therefore, may be of interest to water-works men. The wall is built of reinforced concrete, circular in form, and it was sunk

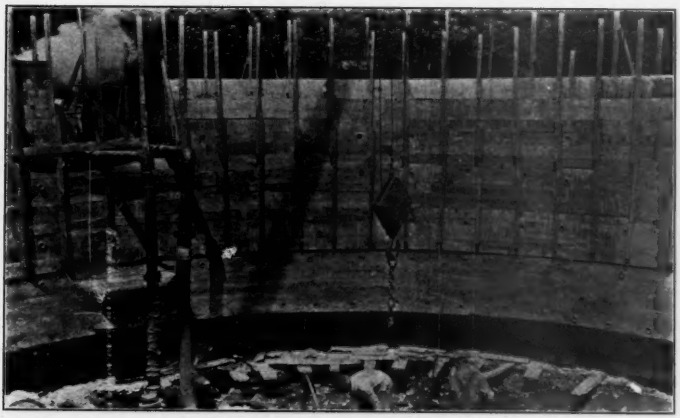


FIG. 1.

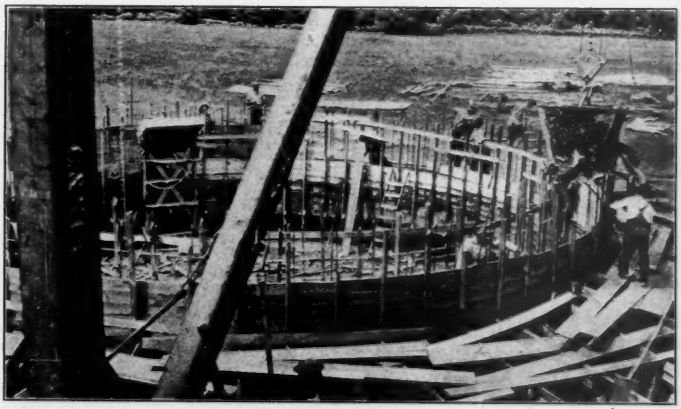


FIG. 2.

CONSTRUCTION OF THE WELL.

into place. The bottom of the wall was designed to act as a cutting edge, and was beveled at the inside lower corner, heavily reinforced. The bevel was made to allow workmen to shovel underneath the edge.

The well is 40 ft. in diameter and 30 ft. deep, twenty-five feet of which is below the ground water level. The first five feet of excavation was made to the water line, and forms were built and the walls of the well constructed about 10 ft. high, projecting out of the ground about 5 ft. Excavation was then carried on inside the well, the water being pumped out; and the wall lowered down by excavation underneath it; also more wall was added to the top until the well was sunk to its depth. It was found necessary to place a pump inside the well, on account of the excessive suction lift, and a centrifugal pump, placed on brackets bolted to the wall, driven by an electric motor and belted connection, was installed. This 6-in. pump worked very nicely under this arrangement, as it was not necessary to lower the suction pipe, the pump following down with the wall of the well as the work progressed. The discharge pipe was constructed in such a way that it would turn on an elbow outside the wall as the well lowered down, without straining the connections. As this pump was about 8 ft. below the ground water level, it was necessary to keep the well pumped out at night.

The well is covered with a reinforced concrete dome, and about 2 ft. of earth, leaving a manhole over the suction pipe. A large number of pieces of $2\frac{1}{2}$-in. pipe were placed in the concrete wall as it was constructed, to allow the water to come through the wall readily.

The pump was built by the Platt Iron Works Company, of Dayton, Ohio, and has a capacity of 3 000 000 gal. per twenty-four hours, against a head of 285 ft. It is a 16 by 18 duplex, horizontal pump, direct connected to a 200 horse-power, slip-ring type, two-speed motor, through a single-reduction or herring-bone gears. After erection, a test was made to determine the mechanical efficiency of the pump, the discharge water being passed through a Venturi meter, and it was found that the plant efficiency was a little better than 75 per cent., which exceeded the guaranty of the manufacturers by 3 per cent.

The cost of electric current, taken on a five-year contract, is 1¼c. per kw.-hr. The present cost of pumping is about $18 per million gallons. The power cost is about $13.50 per million gallons. During the last season we pumped 2 000 000 gal. of water per day from the well for about two weeks, which filled up the lower reservoir more than was consumed; and for the balance of the pumping season we operated the pump during the night hours (one shift) and obtained in this way sufficient water for our needs, about 1.2 million gallons per day.

The system is about eight per cent. metered. Meters are placed on hotels, railroads, manufactories, and any consumption that comes outside of the ordinary flat rate basis. The average water consumption is about 1 200 000 gal. a day, population supplied being 11 500. Through the summer months, when garden hose is used, this is considerably increased; also during cold weather, when people allow water to run to prevent its freezing, it reaches a million and a half gallons a day.

Total cost of work, about $450 000. The total bonded debt is $150 500. Cost of supplying water per million gallons, based on total maintenance plus interest on bonds, $52.68.

It is interesting to note how the last two extensions — the construction of Rocky Mountain Reservoir and the additional supply — have overcome two serious defects, the lack of fire service and the insufficient supply of water, at a reasonable cost.

In connection with this new work, I have worked under the direction, had the hearty support and aid of our able board of water commissioners, Messrs. C. C. Dyer, Wm. F. Aiken, and Thos. L. Lawler. Wm. S. Johnson, civil engineer, of Boston, was employed as consulting engineer in connection with the Rocky Mountain Reservoir, also on work of additional water supply. George A. Kimball, civil engineer, also of Boston, was consulted regarding details of construction of Rocky Mountain reservoir. Allen Hazen, consulting engineer, of New York, was consulted regarding additional water supply.

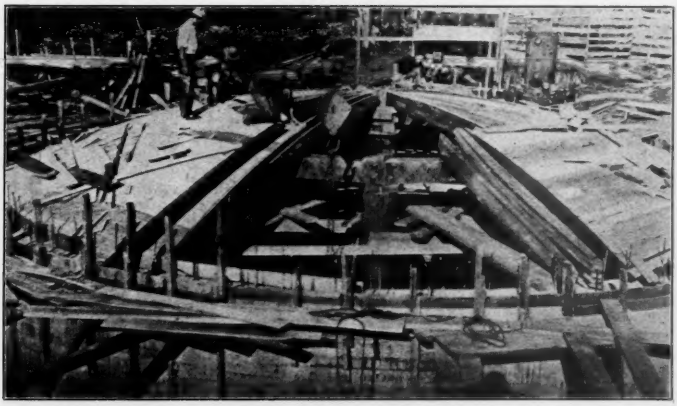


FIG. 1.
FORMS FOR THE DOME OF THE WELL.

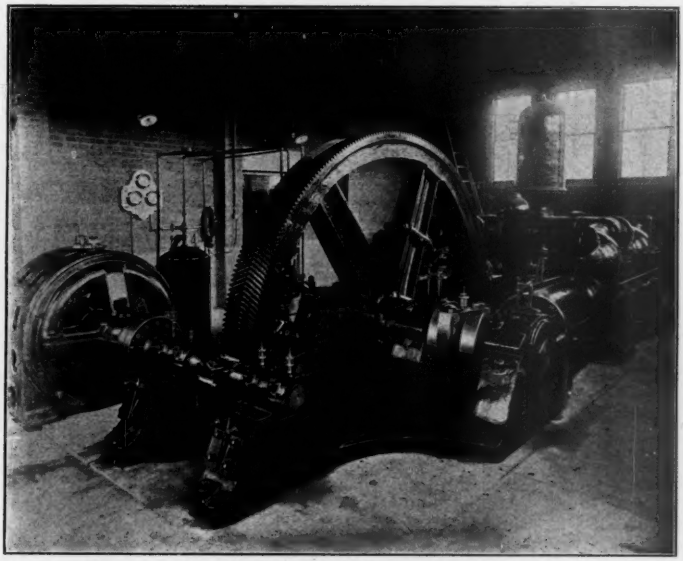


FIG. 2.
VIEW OF THE PUMP.

DISCUSSION.

MR. G. A. SAMPSON. I would like to ask if you had any trouble in sinking your well.

MR. MERRILL. We had no difficulty whatever. The well went down readily. I believe in the case of the first section, which was only about ten feet high, one side of the well got uneven bearings on some bowlders and caused a very slight crack in the wall, probably about one sixty-fourth of an inch. But we saw it before the pressure became great enough to do any damage, and we had no further difficulty. As the well went down, the height of the wall and the reinforcement made it much stronger against a breakage of that sort.

MR. W. S. JOHNSON. In connection with the construction of the reservoir, we had some experiences which might be of interest which Mr. Merrill did not mention. The bottom of the reservoir was entirely upon trap rock, and there were six inches of very rich concrete, which I certainly expected was going to hold water; but when the reservoir was completed the bottom leaked like a sieve, so much so that we could not fill the reservoir. Mr. Merrill got busy, after the contractors got through, and pumped grout into the bottom and made it practically watertight. But it certainly was something which I had not anticipated, that six inches of concrete on that rock, and a very rich mixture, could not hold water under a 20-ft. head. Mr. Merrill speaks of the filter bed beside the Green River. That is hardly a filter bed. The well is located in a comparatively limited deposit of sand of good filtering quality, and this so-called filter bed is simply an area prepared by scraping off the soil, so that the water discharged on it can enter the sand and find its way at a very slow rate to the well. The idea is simply to keep the sand stratum saturated with water and thus keep up the supply of the well.

Greenfield is one of those towns which was unfortunate enough to build water works before the eighties. They didn't know in those days what our modern water-works system meant. The pipes in such systems are always too small, and every town that built works at that time has suffered ever since from lack of sufficient capacity. Of course some of the large cities have rem-

edied that, but comparatively few of the smaller towns, and it is due solely to Mr. Merrill's activity and his method of presenting things so that the citizens could see them, that this water-works plant has been remodeled and made up-to-date. Of course he would have been a good deal better off if an earthquake had come and destroyed the whole plant, so he could have rebuilt, but considering what was there, and considering the fact that the plant was producing a big revenue, he has certainly accomplished wonders. There is one thing, however, which remains a relic of the past, and that is the system of charging for water. They have, as Mr. Merrill says, but very few meters. The water takers seem to feel that they are paying for all the water they can use, and at times they can use a very large quantity.

MR. MERRILL. Regarding leakage of the Rocky Mountain Reservoir, one might infer from what Mr. Johnson said that it was due to defective concrete. This, however, was not the case, as practically all the leakage that we were able to detect was due to contraction of the floor slabs and wall sections, which were all poured in separate sections. The floor slabs were about seventeen feet square, and the wall sections not over twenty-five feet in length.

The concrete was poured during the hottest summer weather, and the reservoir was filled about the first of November, when the water had a temperature of about 45° or 50° fahr. The work of repairs was done during the coldest winter weather, in order to allow the concrete to contract all that the colder water we have during this season would make it.

The repairs were made by drilling holes in the concrete in the joints and inserting a short pipe nipple which was calked in with jute packing so that it would hold pressure. The discharge hose from a grout pump was then connected to the pipe and grout pumped in. In the walls we used pressure as high as 100 lb. per sq. in. It was necessary, as the grout began to flow out of the joints, to calk them with jute packing in the same manner that the joints of a boat are calked.

In one or two cases, while repairing the floor, the grout appeared in joints about fifty feet distant from the drill hole where it was being pumped in. We did not use as high pressure in repairing

the floor as we did for the walls, as there was danger of lifting the floor slabs.

We used about one carload of cement, reducing the leakage from about 400 000 gal. a day to practically nothing.

In connection with the repair work, we were indebted to Mr. A. E. Lockridge, of Springfield, Mass., for advice, and we used the same method used by him in repairs at Springfield.

A DESCRIPTION OF THE WATER SUPPLY SYSTEM OF COHASSET, MASS.

BY D. N. TOWER, SUPERINTENDENT OF THE WATER COMPANY.

[*Read December 9, 1914.*]

Cohasset is a small town, with a population of about 2 600, situated on the shore of Massachusetts Bay, about twenty miles southeast from Boston.

It is almost entirely a residential community, a considerable number of its citizens going daily to business in Boston. There is some truck and dairy farming carried on, but no manufacturing.

Cohasset is noted for the charm of its rocky shore and wooded drives, which have attracted many to build beautiful homes there. We have a good harbor used principally by yachtsmen, although there is a small fishing industry. I mention this to show that salt water has a value as well as fresh water. The ocean adds very much to the popularity of Cohasset as a summer resort for people who love the open sea and are fond of boating and yachting. Minot's Ledge Light is directly outside of the harbor.

It was in the autumn of 1885 that the scheme of installing water works in Cohasset was first started. Of course the first thing to do was to find a water supply, so we employed Mr. Calvin Horton, of Somerville, to come and drive test wells in some meadow land where the indications seemed promising. He drove nine wells which were connected up and a continuous pumping test was made, and while the test did not come up to our expectations it was decided it would warrant going ahead. That winter plans were prepared, the legislature petitioned, and figures obtained from contractors. The work was not actually decided upon until after our town meeting held in March, 1886, when the town took action in regard to hydrants. At that meeting the town voted to pay a yearly rental of $50 each on thirty-six hydrants. It was proposed to put in about six miles of 4-in., 6-in., 8-in., 10-in., and 12-in. pipe, with a reservoir of one and one-half million gallons

capacity on a hill, favorably located in the center of the town, and 163 ft. above high water, which gives a pressure of from 60 to 65 lb. through the town.

The contract for the pipe laying and building the reservoir was given to Mr. William C. McClellan, the pumps and boilers to the G. F. Blake Pump Company, and the well driving and suction mains to Mr. Calvin Horton. The reservoir was built under the supervision of Mr. Freeman C. Coffin, and the writer looked after the pipe laying, etc. Mr. Horton had difficulty in driving the common 2-in. pipe for the wells. They were driven to a depth of from 25 to 45 ft. through a clay hardpan in which were many small bowlders and through a lower strata of clear clay about 20 ft. thick, down to bed rock. On top of the rock was a stratum of water-bearing gravel about 3 ft. in thickness, so there was very small storage capacity in the ground. The supply system consisted of 62 wells, which with the suction lines to the pumps required the following amount of pipe:

1 860 ft.	of	2-in. driven well pipe.
288 ft.	of	4-in. suction pipe.
530 ft.	of	6-in. suction pipe.
678 ft.	of	8-in. suction pipe.
478 ft.	of	10-in. suction pipe.
3 834 ft.		total.

The work was completed and the pump started in December, 1886. Of course we did not have many services the first year, so very little pumping was necessary to keep the reservoir full.

After two years I began to be bothered with air in the suction mains, which caused the pump to pound. This was very annoying, and after giving some thought to the trouble I conceived the idea of separating the air from the water before it reached the pump. I had a small air pump built and connected with an air chamber of 6-in. pipe about 6 ft. high leading from the top of the 10-in. suction main, which was 478 ft. long, from the sand chamber to the pump. I assumed that the air in flowing through the pipe would rise to the top and flow along in the form of air bubbles. By maintaining an air-pump vacuum slightly greater than the vacuum on the main pump, this air would be drawn

away from the water. I found this plan worked very satisfactorily, and the pump ran as smoothly as though I was drafting from a pond.

Each year the number of services and the demand for water increased, so that I had to draw harder on the wells, and soon found that my air pump was not able to handle all the air, so I put in a second air chamber and pump, which combination answered for about two years. I then had to give up these two small pumps and put in a large 12-in. by 12-in. vacuum pump, which has done the work until the present time. The supply from our original wells was adequate for our needs until 1897, when the question of more water was forced upon us.

Wells were then driven in various places about the town, and every place where there was any indication of water was tested. The soil in Cohasset is very unfavorable for the storage of ground water, it being composed in most cases of clay and sand or ledge; very little gravelly formation is to be found. In a small meadow in the center of the town, we obtained very good results from seven $2\frac{1}{2}$-in. driven wells about 30 ft. deep. A small pumping station of frame construction was built and a $13\frac{1}{2}$ h.p. Hornsby-Akroyd oil engine was installed, with a 7-in. by 8-in. single-acting triplex pump. Here again I was bothered with air, although not from the pounding of the pump as at Station No. 1. In this case, the air being forced into the mains caused the water all through the system to look like milk. An air pump remedied this trouble. Here we obtained 200 000 gal. of water a day, and with this addition to our supply we got along for four years more, but during the latter part of this time we were pretty close to the wind at times, so it was again forced upon us to look for more water.

We have a pond about 57 acres in area and 6 ft. deep, called Lily Pond. It is fed by a brook which has its source in Norwell, and has a considerable drainage area besides. This pond is mostly surrounded by trees, and the bottom is very muddy, so that the water has a color about the same as weak tea. The State Board of Health was consulted in regard to taking water from this pond. They reported that while it was not very satisfactory in color there was nothing harmful about it, and that I might use it as an emergency supply to help me over a time of shortage with

my other supplies. It was then decided to build a third small pumping station here and put in a 13½ h.p. De La Vergne engine, the same make and size as in Station No. 2, and a 7-in. by 8-in. single-acting triplex pump. One year of this was enough, as the water caused great complaint among the takers when we were forced to use it.

Moore & Co. at that time became actively interested in the plant, and they proposed building a gallery at the edge of the pond near the pumping station. Wells were driven along the proposed location first and then a gallery 200 ft. long, 12 ft. deep, and 8 ft. wide was built. It was stoned up about 4 ft. and the balance of the sides and top was of concrete. The material in which this gallery was dug was of clay hardpan, so that the flow of water into it from the pond and the high land adjourning was slow. This supply is limited, so that the pump can be run only about fourteen hours out of the twenty-four. I figure that this supply gives us about 200 000 gal. a day. With these three supplies we continued for three years more, when it was made very evident that we must obtain still more water as our takers were increasing, and many of the summer people were using a great quantity of water on their large lawns.

Mr. W. S. Johnson was then employed to look over the ground and advise us in the matter, and under his direction a number of test wells were driven. Even where water could be found in abundance it was impossible to obtain it from driven wells on account of the sandy formation which prevented a good flow. Mr. Johnson advised digging a test well, which was done. A well 6 ft. by 12 ft. and 15 ft. deep was dug at a point between upland and meadow in a part of the town called Beechwood, where the prospects seemed best for obtaining a supply of water. A steam pump was connected with this well, and after pumping a short time it was found that this water carried a large amount of iron, so this location for a well was given up.

Mr. Johnson then proposed going back into the upland about three hundred feet to try again. A second well was dug about the same size as the first, and here we obtained very satisfactory water. Mr. Johnson did not feel wholly satisfied with this test, however, and had the well put down to a depth of 25 ft. and a

thorough test made by pumping continuously night and day for a month or more. The water continued to prove satisfactory, so it was decided to enlarge the well to 25 ft. in diameter and 25 ft. deep, to build a brick pumping-station and lay about two miles of 10-in. pipe through a street where there was quite an amount of ledge. This work was completed by Moore & Co. in 1909, and the pump was started up just before our annual convention. I started on this excursion feeling quite easy in my mind, thinking that our water question was settled permanently. You can imagine my surprise upon returning home to find the plant shut down for the reason that a large amount of iron had suddenly developed in the water. This was a great disappointment after going to the large expense of putting in this plant. In this station, No. 4, was installed a 25 h.p. Meitz & Weiss oil engine and an 8-in. by 10½-in. triplex pump which would supply 500 000 gal. a day.

Mr. Johnson was soon on the job again, and after looking over the situation he proposed digging a natural filter bed in the ground, on the line of upland and meadow and about two hundred feet from the well, connecting this filter with Bound Brook.

This brook has a history attached to it, as at one time it was a division line between two colonies, Plymouth Colony and Massachusetts Bay Colony; and between two counties, Plymouth County and Norfolk County; and also between two towns, Scituate and Cohasset. The water in this brook has considerable color, as it flows for a long distance through woods and swamps. The bottom of this filter was about 6 in. below the bottom of the brook, a connecting ditch being dug. Mr. Johnson had figured that the brook water percolating through the ground from this filter into the well would act as a blanket, as he expressed it, on the swamp water from which the iron appeared to come, and prevent it from flowing to the well. An improvement appeared at once in the water after the filter was made, showing that it was working out just as Mr. Johnson had expected; but the result was not as satisfactory as he had hoped for, so he advised that we make as many filter beds as we had room for on our land and pump Lily Pond water on to them, as the brook in a dry time would not furnish an adequate supply.

In 1910 three additional filters, each 75 ft. by 100 ft. and about 4 ft. deep, were dug, and a 10-in. spiral riveted pipe was laid through a swamp for a distance of 2 600 ft. to the south side of Lily Pond, where Station No. 5 was erected, in which was placed an electric motor and centrifugal pump.

As only 18 horse-power of the engine in Station No. 4 was used in running the main pump, the other 7 horse-power was utilized to run a generator. This gave us current for operating the motor driving the centrifugal pump at Station No. 5 which supplied the filters with water from Lily Pond. We put in a 7 h.p. generator at Station No. 4 and a 5 h.p. motor at Station No. 5. When this arrangement was put into operation, we found that the amount of iron in the water was very much reduced, but at the same time I had a great deal of complaint from the water takers in regard to the quality. At times the water would be very dark colored and very unpleasant to taste. It caused a brownish deposit in the mains, and when a hydrant was opened the water would come so muddy that I was obliged to flush the mains very often. We got along in this fashion until 1913, when it was decided that something more must be done to improve the water, and advice in this matter was asked of Mr. Robert Spurr Weston.

Mr. Weston used an experimental filter which was set up in the pumping station, and the pump was run continuously about all that winter to supply the filters, the surplus water running to waste. Mr. Weston experimented with and without chemicals, and made a great many tests under different conditions. When the tests were completed he reported that the larger part of the iron could be removed by aëration and sand filtration without the use of chemicals.* It was decided to adopt his recommendations and build a filter plant from his plans. The contract for the whole work was given to the Norwood Engineering Company, of Florence, Mass. They sublet the brick and concrete work to the Briggs Construction Company, of Providence, R. I.

The work was commenced the latter part of March, 1914, and it was finished with the filter plant in operation the last of July. The installation has worked very satisfactorily. The water takers have been pleased with the improvement in the water, and now

* JOURNAL N. E. W. W. A., Vol. 28, p. 31.

I think we have an ample supply of good water which will answer our needs for some time to come.

At the present time I have only 675 services, and to supply them I have five pumping stations. In the first station there is one 8½-in. by 12-in. compound duplex steam pump, a 12-in. by 12-in. air pump, together with feed and vacuum pumps. In Station No. 2, one 13½ h.p. De La Vergne engine, a 7-in. by 8-in. triplex pump, and air pump. At Station No. 3, another 13½ h.p. De La Vergne oil engine, a 15 h.p. electric motor for emergency, and a 7-in. by 8-in. triplex pump. At Station No. 4, a 25 h.p. Meitz & Weiss oil engine, a 20 h.p. electric motor for emergency, one 8-in. by 10½-in. triplex pump, one 7½ h.p. motor and centrifugal pump combined for pumping from the well to the aërator, one 10 h.p. motor and air pump combined to furnish air when washing the filters, and a 3-in. by 3-in. air pump run by water motor from the main pipe which gives from 80 to 100 lb. of air pressure for starting the engine.

It was soon found that pumping water from Lily Pond to the filters in addition to pumping to the reservoir overloaded the 25 h.p. engine, so a change was made by buying electric current and installing a 10 h.p. motor at Station No. 5. I have not used Station No. 5 to pump water from Lily Pond to the old filter beds since the new filter plant has been in operation. I have been using straight ground water from the well, with all the iron that it carries, trusting to the new filter plant to remove it.

If I should be obliged to run night and day, it is more than possible that I should have to pump from Lily Pond on to the filter beds to keep up the supply in the well. Plants Nos. 2 and 4, which have oil engines, are run night and day when necessary without stopping and without attention other than to look them over two or three times a day, fill oil cups, etc. It is unusual to find one stopped, but if I do I am always happily disappointed when it starts up at the first try without requiring the piston to be taken out and a general overhauling in order to locate the trouble, although when found it is usually very easy to remedy. There are now seventeen miles of main pipe and eighty-three hydrants.

If any one here has a larger assortment of machinery for providing so small an amount of water, I should like to hear from him.

DISCUSSION.

MR. ROBERT S. WESTON. There are some important points in connection with Mr. Tower's paper which might be emphasized. Cohasset is a singular town. Geologically, it consists of a number of rocky pinnacles projecting above the surface of the sea and forming a series of depressions between them. In these depressions nature has dumped more or less material, largely sand and gravel, and the water-bearing strata are contained in these water-tight depressions in the rock. This explains Mr. Tower's statement that he had five pumping stations. The practice has been to tap these little pockets of sand and gravel and extend the works by sinking wells in new pockets.

Many of you know that the water company attempted to take a highly colored water from Lily Pond and purify it by mechanical filtration. This proposition, however, was disapproved by the State Board of Health because they feared the plant was too small to afford adequate supervision.

In the western part of Cohasset the rocky depressions cease, and a region of ponds and dark-colored streams, which latter drain swamps, begins. Naturally, any attempt to win a ground water from the vicinity of these swamps is attended with some danger. This was the case at the Beechwood pumping station. For a while, as Mr. Tower has said, the ground water was practically free from iron, but as the draft increased the water which was beneath the peaty deposits in the swamps reached the wells; iron appeared in the supply, and the measures which Mr. Tower has described became necessary.

The speaker had the good fortune, a couple of months ago, to visit Mr. Tower's works, and observed that the water coming from the filter was perfectly clear and undoubtedly free from iron. Everyone hopes that Mr. Tower has reached the end of his troubles. Having gone from the region of the rocky pockets with their inadequate supply, he has adopted a method which will enable him to use indefinitely the more abundant water from the ponds and their vicinity.

MR. HUGH MCLEAN. Mr. President, I would like to ask Mr. Tower whether the system is metered.

MR. TOWER. We have fixed rates, except that about twenty meters have been placed on a few of the large summer places. We have many city residents who get there about the first of June and are there perhaps until the middle of October, who have large lawns, with shrubbery and flowers, and are large users of water. I thought I could increase their rates by putting on meters, but in only a few cases was there any increase, as their fixture rates were large, which gives them a large quantity of water during the summer by meter rates. So it is about an even thing. Then there is the cost of setting the meters, which in some cases have to be set in the road on account of having so many outlets between the road and the house. They averaged up about the same as by fixture rate.

MR. W. S. JOHNSON. I would like to suggest to Mr. Tower that he might meet the situation with regard to summer residents as one other Massachusetts town has, where they have just put in force a rate of 30 cents per thousand gallons during the winter months and a rate of 50 cents per thousand gallons during the summer months.

In regard to the situation in Cohasset, while the rocks certainly do add to the picturesqueness of the sea coast, they make that town the worst, without exception, which I have ever found in which to get a water supply. It exists, as Mr. Weston has said, only in small pockets, between the rocks, and in the pond described by Mr. Tower, where the water has the color of tea. I believe that Mr. Weston has solved the problem of purifying this water, and I certainly hope, for Mr. Tower's sake, that he won't have to add a sixth pumping plant.

THE STANDPIPE AT WESTERLY, R. I.

BY THOMAS MC KENZIE, SUPERINTENDENT OF WATER WORKS, WESTERLY, R. I.

[*Read March 10, 1915.*]

There probably has been no one thing more radical in its departure from old-established methods of construction in the water-works field than the substitution of concrete for iron or steel for standpipes and water towers. Up to within a comparatively few years the use of concrete for this purpose was practically unknown.

The standpipe at Attleboro, one of the pioneers in this type, was constructed in 1904, and since that time there have been erected in New England quite a number of reinforced concrete standpipes, varying from 32 to 100 ft. in diameter and from 16 to 104 ft. in height, and with capacities of from 108 000 to 2 000 000 gal.

It would seem, therefore, with this wide variation in sizes and capacities, there would now be sufficient practical knowledge on the subject upon which to base our deductions as to their desirability.

The unattractiveness of an iron standpipe cannot be questioned, and it is not to be wondered at that water-works engineers and city and town officials are anxious to find something to replace the iron structures that are so common. The water-works manager, also, I am sure, would gladly welcome a type of construction that would relieve him of the disagreeable work of cleaning and painting his iron standpipe. I say disagreeable, because if he survives the task of satisfying himself, his commissioners, and Citizen Fixit, which one of the fifty-seven varieties of rust-proof paints or compounds is the best for his particular case, he is still up against the problem of determining whether the pitting from corrosion has progressed so far, since the last time he saw it, that the factor of safety now looks to him like minus five.

Quite naturally we are attracted to the picture of a beautiful white standpipe, one that never grows old in the sense of deterioration. The longer it stands there, the more solid and enduring it becomes. It will never require painting, and consequently will not have to be emptied; always full, always ready.

The picture is ideal. Its attainment, I regret to say, is not always accomplished.

The water-works system of the town of Westerly, R. I., was originally built by a water company in 1886 to supply the compact part of the town with water. In 1887 the works were extended to supply the village of Pawcatuck in the town of Stonington, Conn.

The original supply was taken from Shunoc Brook located in the town of North Stonington, Conn. The water flowed by gravity through a 16-in. conduit, 5 260 ft. long, from the brook to the pumping station located near the village of White Rock in Westerly, and was pumped from there through about 13 000 ft. of 12-in. main to a wrought-iron standpipe located on what is locally known as Quarry Hill.

This standpipe, built in 1886 by the Robinson Boiler Works of Boston, Mass., is 30 ft. 6 in. in diameter and 70 ft. high, the water line being 210 ft. above the pumping station, and has a capacity of 380 000 gal.

In 1897 the water-works system was purchased from the original water company by the town of Westerly. Preceding the purchase of the works, investigations were made by the town relative to procuring a new supply, which resulted in adopting the present supply from driven wells, located near the Pawcatuck River. A new pumping station was built, new pumping engines installed, and the old surface brook water supply was abandoned in 1897.

The adoption of the driven well supply necessitated covering the standpipe, and the present roof was constructed on the iron standpipe in 1898.

The consumption of water, at the time of the purchase of the works in 1897, was approximately 400 000 gal. per day, and with two new 1 000 000-gal. pumps, this standpipe provided ample storage.

In 1902 the works were extended to Watch Hill, a shore resort,

or summer colony, located on Little Narragansett Bay, about five miles from Westerly, and by 1910 this, with other local extensions, resulted in an increased consumption of water, during the summer months, to approximately 1 000 000 gal. per day.

The question of additional storage was taken up by the water department, and as the topography of the surrounding country precluded all possibility of a storage reservoir, it was decided to construct another standpipe as near to the present one as possible, the plan being to use both standpipes during the life of the old iron one, and to have the overflows level.

Specifications for a wrought-iron standpipe, and also for a reinforced concrete steel standpipe, were prepared for the water department by Mr. Samuel M. Gray, consulting engineer of Providence, R. I., and proposals were invited for the construction, under these specifications, of a standpipe 40 ft. in diameter and 70 ft. high to the overflow line.

Two proposals were received for the construction of a reinforced concrete standpipe and two proposals for a wrought-iron standpipe.

On the recommendation of the consulting engineer, the contract for a reinforced concrete standpipe was awarded to the Aberthaw Construction Company of Boston, Mass., in accordance with a plan submitted by them, for the sum of $17 760. Subsequent to the signing of the contract, some revisions were made in the plans, enlarging the cornice for architectural effect, which added $962, making the total contract price $18 722.

A water-works standpipe is not generally considered a thing of beauty. On the contrary, they are often spoken of as a blot on the landscape, a necessary evil that, in the case of an iron structure, depending upon the individual tastes of those happening to be in authority, may be a dark red, a dreary black, or a battleship gray.

On the other hand, a leaky concrete standpipe is certainly no improvement, and when in addition to the unsightly appearance is added the feeling of insecurity, which leakage in a structure of this character naturally creates, there is not much that can be said in its favor.

It is, therefore, not the intention of the writer to enter into any

details regarding the relative merits of a reinforced concrete standpipe or an iron one, or to offer any suggestions as to the desirability of either type over the other.

The location in a residential district, the possible architectural features, together with the probable advantage in protection and expense of not having to empty the standpipe for cleaning and painting, and the permanence of the finished structure, were the main factors in determining, in this case, the preference for a reinforced concrete standpipe.

The possibility of having a standpipe with leaky walls seemed to be covered by a clause in the specifications requiring the contractor to "guarantee the safety of the structure and the absence of leakage for the term of one year."

The specifications also stated, "It is not the desire of the water commissioners to build a structure with extremely thin walls, and no bid with walls less than 14 in. thick at the bottom will be accepted, and they may be thicker."

The site selected for the new standpipe was about 500 ft. from the old one, and the work was commenced by the contractors in May, 1910. The excavation for the foundation was carried down about 6 ft. below the surface of the ground, the last 2 ft. being in hard pan. The inside diameter of the standpipe is 40 ft., the height from the floor to the overflow is 70 ft., and from the ground to the top of the ventilator about 88 ft. The walls are 4 ft. thick at the floor line, tapering to 14 in. at a point 5 ft. from the floor, and continue this thickness up to the water line.

An access chamber, 13 ft. long and 4 ft. wide, with a square manhole opening 2 ft. by 4 ft. on the outside and a 30-in. round iron manhole cover on the inside floor, is provided as a means of access to the interior of the standpipe.

The roof is a Guastavino dome of dark red glazed tile and is 41 ft. in diameter and 13-ft. rise. A manhole $2\frac{1}{2}$ ft. by $3\frac{1}{2}$ ft. in the roof also provides a means of access to the interior of the standpipe.

A steel ladder 1 ft. wide runs up the outside of the standpipe. This ladder was erected in 16-ft. sections and is fastened to bronze bolts in cast-iron sockets with 1-in. bronze faces set into the wall at 16-ft. intervals.

The frame tower used by the contractors for conveying the material was large enough for a one-yard Ransome bucket, operated by a hoisting engine. The concrete was mixed in a No. 2 Smith concrete mixer, set in a pit, so that the materials could be dumped into the hopper from the ground. The floor reinforcing consists of $\frac{1}{4}$-in. square rods, 6 in. from center to center both ways. These rods are 1 in. below the floor surface and are bent up 4 ft. into the wall. The main reinforcement is of plain, round, mild steel bars $1\frac{1}{2}$ and $1\frac{1}{8}$ in. in diameter. These bars are 71 and 69 ft. long, so that two form a complete ring, allowing forty diameters for lap, and are held in place by two Crosby clips, such as are commonly used for guy wires. The bars, or hoops, were supported by twelve $1\frac{1}{2}$-in. vertical iron pipes placed 30 degrees apart, and resting on standard 6-in. flanges on the floor. These pipes were coupled in 3-ft. lengths as each successive form was set up. To secure the required spacing of the hoops, $\frac{1}{4}$-in. holes were drilled in the vertical pipes at the proper intervals and hooks placed in these holes, upon which the hoops rested.

Other reinforcing consists of $\frac{5}{8}$-in. round and $1\frac{1}{4}$-in. square rods around the manhole and roof of the access chamber, $\frac{1}{4}$-in. square rods set horizontally, and $\frac{5}{8}$-in. round rods 4 ft. from center to center under the dome seat and bent out into the cornice, and round $\frac{5}{8}$-in. rods, 7 ft. long and 2 ft. from center to center, run vertically up into the parapet wall.

The material used for the concrete was Vulcanite cement, crushed granite, and bank sand. Every precaution and care was used in the selection of materials and in mixing and placing the concrete to secure watertightness. Experiments and tests were made on the ground for proportioning the aggregates composing the concrete to secure the maximum density, dependence being placed on this to make it impervious.

From the results of these experiments, a mixture approximating $1:1\frac{1}{2}:3$ was used for the walls. Tests of the voids in the sands and stone showed that the volume of cement was 10 per cent. in excess of the voids in the sand, and the volume of mortar was more than 10 per cent. in excess of the voids in the stone, as was required by the specifications.

Particular care was given to the bond in the joints. The surface of the concrete was thoroughly cleaned after it had taken its initial set, and a 1-in. layer of 1:3 mortar was carefully spread over the joint before the concrete was poured. Five per cent. of Limoid (hydrated lime) by weight of the cement used was added for waterproofing.

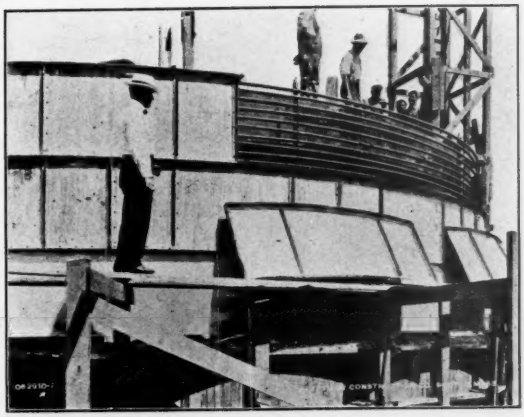
No outside staging was used, the work being all done from a movable platform inside of the standpipe, which was raised by eight differential chain falls as the work proceeded. Wooden forms were used for the base up to the top of the molding, and from this point to the overflow line steel forms were used. These forms were made of $\frac{1}{8}$-in. plate, riveted to $2\frac{1}{2}$ by $2\frac{1}{2}$ in. angle irons, bent to the proper curve. The use of these forms, which was entirely successful, produced a very smooth, uniform finish on the outside of the standpipe.

Many interesting problems of construction were successfully worked out by the contractors, and a description of these problems, together with detailed accounts of the materials used, the calculations for stresses in steel reinforcing, the proportioning of the concrete, unit tables of cost, etc., have been described in a paper and discussion by Mr. L. C. Wason, M.Am.Soc.C.E., president of the Aberthaw Company, before the Boston Society of Civil Engineers*; also in a paper† by Mr. W. W. Clifford, Jun.Am. Soc.C.E., of the Aberthaw Company. These papers and discussions so thoroughly cover all of the details of the construction of this standpipe, the writer has simply tried to give in a general way the principal features of the work.

Water was admitted into the standpipe during construction as a means of safety for the workmen, and the only signs of any leakage, while the construction was going on, was a small leak of minor importance near the bottom of the standpipe, very close to the floor. Upon the completion of the work, this water was drawn out of the standpipe to remove the posts and bracing used in supporting the platform and the débris accumulated in the bottom.

The standpipe was then again filled with water on August 25,

* Journal Assoc. Eng. Societies, *46*, 401, 1911.
† Trans. Am. Soc. C. E., *74*, 375, 1911.



SHOWING FORMS AND REINFORCING, WESTERLY STANDPIPE.

1910, and three or four small leaks immediately developed, the principal one being on the joint at the top of the molding. It was at this joint that the steel forms were first set up. The other two leaks were small wet spots, which appeared through the blocks of concrete and were not at joints. These were later plugged up with grout under gas pressure from a carbon dioxide gas tank, and were successfully stopped.

The leak on the joint on top of the molding appeared as a horizontal crack, running nearly one third the distance around the standpipe on the south and east sides, and was apparently caused by a movement of the wall. The leakage was very small, just sufficient to dampen the surface and stain the top of the molding.

The standpipe was put into use until September 20, 1910, when the water was drawn off and an effort was made to waterproof the inside surface with hot paraffine. The process consisted of heating the inside surface of the wall with a hot charcoal fire contained within a wire basket, which was drawn up and down the surface of the wall until it became hot, then hot melted paraffine was applied to the wall with a wide, flat brush, the heat preventing the paraffine from hardening before it penetrated into the surface of the concrete. The wall was then reheated, forcing the paraffine into the pores of the concrete, the process being repeated several times. This process was applied to the floor and 8 ft. up the sides and later carried up 10 ft.

The work was not successful, however, for upon filling the standpipe, the leakage still continued and at this time the crack had increased in length, now being nearly one half the distance around the tank; there was also a trifle more water. More leaks began to develop, all at the joints, and all but one or two on the south and east sides of the tank.

A still further effort was made to prevent the leakage by an application of plastic slate. This method consisted of a belt of plastic slate, 2 ft. 8 in. wide, around the pipe, centering on the crack. It was made up of one ply of plastic slate put directly on to the pipe, then one ply of paper, one more of plastic slate, another of paper, and a finishing ply of plastic slate, the last ply of plastic slate to have enough of the slate dust in it to make it fairly hard and ready for the water.

Unfortunately, this method of treatment was also not a success. While some of the leakage was stopped, it was by no means all stopped, and the preparation made the water taste so bad that we were obliged to discontinue the use of the standpipe and waste the water.

It was now a noticeable fact that each successive time the standpipe was emptied and filled, more leaks developed, all of which were at the joints, that is, at the junction of one day's work with another. These leaks were mostly on the south and east sides of the standpipe.

It was now apparent that nothing short of complete waterproofing of the entire interior would make it watertight. A contract was made by the builders with F. W. Bird & Sons, who guaranteed their material not to make the water taste in any way.

The work was commenced on October 16, 1911, and completed on December 18, 1911. It consisted of the usual method of waterproofing. A specially prepared Neponset compound was applied hot to the wall of the standpipe and then covered with water dyke felt, five successive layers being built up in this way. The work was carried from the bottom of the standpipe to above the overflow line and was accomplished by means of a barrel float, water being let in to raise the float as each successive layer was applied.

The work was entirely successful. The water used in floating the stage was drawn off, the standpipe refilled, and on December 26, 1911, was put into service. No signs of any leakage have developed during the three years of continuous use the standpipe has now had. The area covered was 10 082 sq. ft. The total cost of the waterproofing was $1 782, or 16½ cents per sq. ft.

There have been some twelve or thirteen reinforced concrete standpipes built in New England, and in nearly every case there has been more or less seepage, amounting in a great many cases to considerable leakage. By leakage I mean water spurting out or running down the sides in streams, a condition that never existed at any time with the standpipe in Westerly.

The intelligent use of the aggregates to determine the voids in the sand and stone, and fixing the proportion in which they were used, produced an impervious concrete, so that no unusual diffi-

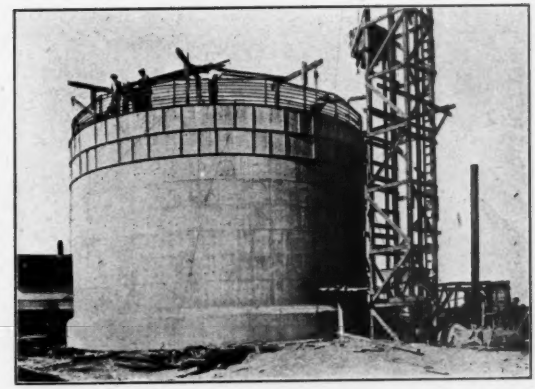


FIG. 1.

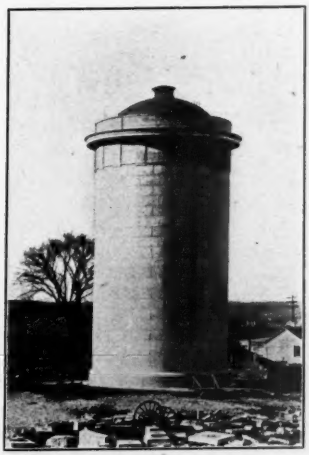


FIG. 2.

THE WESTERLY, R. I., STANDPIPE.

culty was experienced from this part of the work. The seepage at the joint, on top of the molding, was undoubtedly caused by the rigid connection of the wall with the floor, which prevented the stretching of the wall under pressure without breaking the bond. It has been suggested that this difficulty can be overcome by disconnecting the bottom of the standpipe and the circular wall, allowing the wall to expand and contract on a slip joint, the joint to be made watertight by the use of elastic asphalt.

In the *Engineering Record* of January 10, 1914, there is a description of a standpipe at Fulton, N. Y., 100 ft. high and 40 ft. in diameter, designed by Mr. William Mueser, M.Am.Soc.C.E., in which this method of construction was adopted. The writer would be glad to know how the theory worked out in practice.

The leakage at the joints, which occurred in increasing numbers each time the standpipe was emptied and filled, was no doubt caused by temperature stresses, because these leaks were always on the sunny side of the standpipe.

The difficulties in securing an absolutely watertight reinforced concrete standpipe would seem to lie in the tendancy to vertical cracks, or breakage of the bond, at the point where compression in the floor changes to tension in the wall, and the unequal tension between the steel and concrete, when subjected to varying temperature stresses.

DISCUSSION.

MR. H. B. ANDREWS. Mr. President, I would like to ask Mr. McKenzie if there isn't danger of the rise and fall of ice in the standpipe scraping off the waterproof coating.

MR. MCKENZIE. We take our water from driven wells, and the temperature of the water is 54 degrees winter and summer. We have now been through three winters, a year ago this winter being exceptionally severe, and so far as I know at no time has the ice formed in the standpipe. So that in our case I think the danger from that cause is very slight.

MR. ANDREWS. If ice should form, as it does in other standpipes, would it not scrape the coating off?

MR. MCKENZIE. I should hardly say that, because the last application of asphalt produces a very smooth surface on the inside

of the pipe. The only difference that I could see between the application of asphalt and the application of cement is in the color — one was black while the other would be white. The coating was so smooth that it seems to me if ice should form it would not scrape off the coating.

ATTLEBORO'S REINFORCED CONCRETE STANDPIPE.

BY H. F. CONANT.

[*Read March 10, 1915.*]

One of the first matters called to my attention by the commissioners after my appointment as superintendent of the Attleboro Water Department, in April, 1912, was the condition of the concrete standpipe. Although not serious, it was nearing the time when repairs would be necessary to stop the scaling off of concrete on the outside, and leaks which had been going on ever since the tank was built in 1905, and seemed to be increasing.

I at once began to study the cause of the scaling and leaking and what had been done to prevent it. I learned from the reports of the commissioners that the scaling was in evidence almost as early as the leaking, and that considerable work had been done to prevent it. Referring to the commissioners' report of 1906, I found the following:

"On December 27, 1905, we put the new standpipe into commission, and continued to use it until May 15, 1906. The leaks during that time were very trifling, although during extreme cold weather we noticed a scaling off on the outer surface at certain points, beginning five feet from the bottom of the tank and extending to a point about fifteen feet from the bottom of the tank. This was apparently caused by pockets or cavities that must have existed on the outside of the steel, probably caused by the slight moving of the forms when the concrete was being placed.

"About May 15, 1906, the Aberthaw Construction Company began the plastering on the inside of the standpipe. The first coat had 2 per cent. lime to one part cement and one part sand; the other three coats were composed of one part sand and one part cement. This was floated until a hard, dense surface was produced; then this surface scratched to receive the succeeding coat. This work was done by experts in that line.

"Prior to the plastering the entire inside of the standpipe was thoroughly cleaned and then picked. This was done to insure the bonding of the cement plaster to the surface. There were four coats of plaster put on, and we felt reasonably sure that it would

be perfectly tight, as great care was used in applying the same. But upon filling the standpipe this did not give us the result we expected, as we had felt positive that we should have an absolutely watertight structure.

"At the time the inside work was being done the outside, where the cement had scaled off from the effects of frost, was repaired by digging around the outside row of steel reinforcement, putting on iron clips made of $\frac{3}{4}$-in. by $\frac{1}{8}$-in. iron bolted through, and then cement was forced into the cavities around these clips by throwing it a distance of four or five feet to insure the filling of the voids. This process was continued until the cement covered the entire outer surface, so that further plastering could be perfectly bonded; on this surface was placed expanded metal, forced over the clips that stood out horizontally, and then a coat of plaster was carefully troweled over the surface of this metal, and then a coat of metal placed outside of that plastering, the ends of the clips being turned at right angles to hold the same in place. After this the final outside coat was applied, thus making a very firm and compact surface equal to any part of the structure.

"After noting the result of the interior plastering, we were satisfied that some other method must be used to make the standpipe perfectly tight under one hundred feet head, at the same time realizing that in a warmer climate we should not hesitate to accept it as it was.

"Upon consulting with our engineer and contractor we decided to coat the inside with what is known as the "Sylvester process" wash. We presume many of you are familiar with the same, but for the benefit of those who are not, we will give the formula used on this standpipe.

"Dissolve $\frac{3}{4}$-lb. castile soap in one gallon of water. Dissolve 1 lb. pure alum in eight gallons of water. Both must be thoroughly dissolved. Before applying to the walls the surface must be perfectly clean and dry; temperature must be about 50 degrees Fahrenheit. First, apply soap at boiling temperature with a flat brush, taking care not to form a froth. Wait twenty-four hours so that the solution will become dry and hard upon the walls, then apply the alum in the same way, at a temperature of 60 to 70 degrees Fahrenheit. Wait twenty-four hours, and repeat with alternate coats of soap and alum.

"On the Croton work, four coats of each solution rendered the walls impervious. According to the report made by Mr. Dearborn, a pound of soap will cover about 37 sq. ft., and one pound of alum will cover about 95 sq. ft. Water may be admitted to the tank as soon as the last coat becomes hard and dry.

"This solution has been used with good success on a number of

FIG. 1.

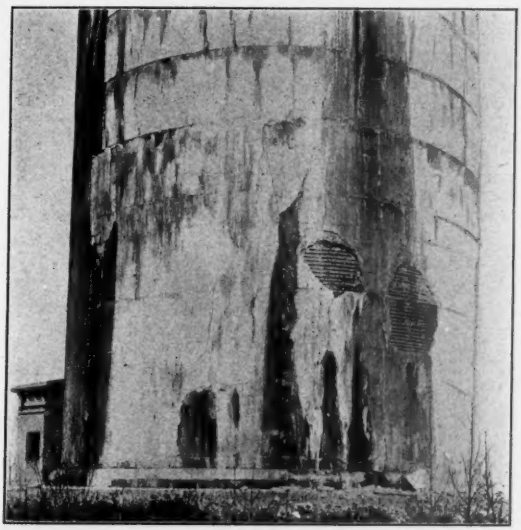


FIG. 2.
THE ATTLEBORO STANDPIPE. SPRING OF 1914.

reservoirs, not exceeding a 40-ft. head, making them absolutely tight.

"In order to test this process we decided to try 35 ft. of our standpipe from the bottom up. After applying four coats of the mixture we filled the standpipe full and at 100 ft. head we found there were only four leaks in the 35 ft. coated. On account of this success, we decided to apply four coats more to this same surface, that making eight coats from the bottom up to 35 ft., and above that distance four coats. The result was very satisfactory, but not absolutely tight. As the contract called for a watertight structure, the contractors decided to apply five more coats over the entire surface, thus making thirteen coats for 35 ft. and nine for the rest of the structure. On October 28 the standpipe was filled and found to be practically tight, as the slight wetting on the outside was due to the condensation of the atmosphere. Later a few leaks developed which seemed to come from the inside, but these varied from time to time during the next month. Under certain conditions of the atmosphere the entire surface was absolutely dry; under different conditions it would show a slight leakage. This was so gratifying to the commissioners and engineer that on December 6, 1906, the standpipe was accepted from the contractors under conditions named in contract, viz., to maintain the structure one year from date of acceptance, and if the same continued satisfactory during the winter they were to clean down the outside and wash with neat cement."

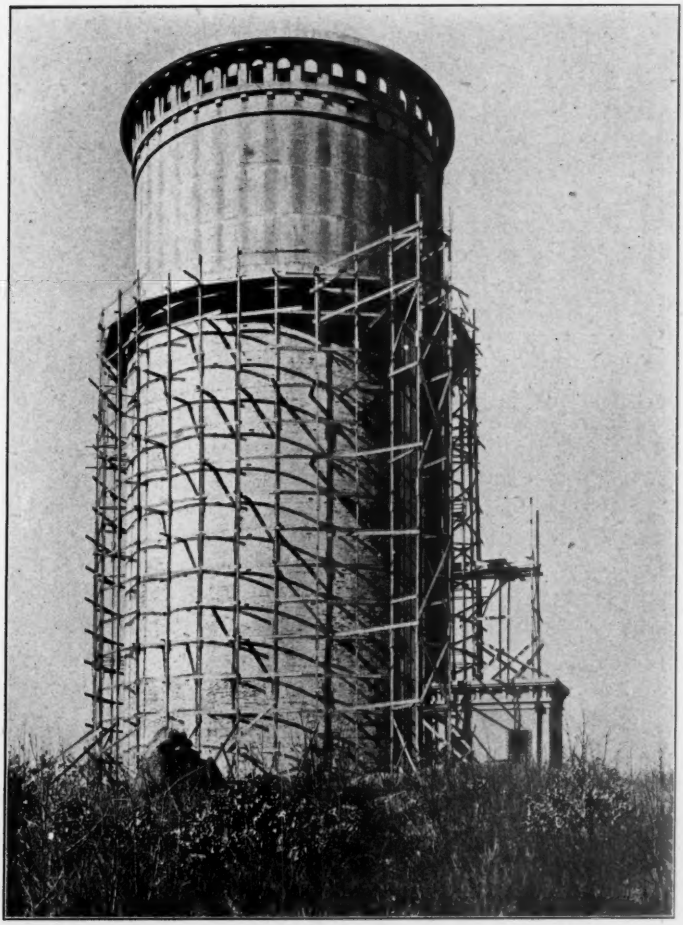
After a careful study, I made up my mind that the main cause of the leaking was due to expansion and contraction, for from observation it had been noted that the leaks varied from time to time, a condition also noticed by the commissioners in 1906, when they were experimenting with plaster and later with "Sylvester process" wash. Another reason for my belief in expansion and contraction was that all reinforced concrete standpipes which I have seen or have data on show more cracks and are in much poorer condition, externally, on the south side than on the north, because of more change in temperature. The hot sun pouring down against the south side of a tank at noonday and the cooling off during the night keeps the concrete in constant motion. Variation in temperature is not the only cause of expansion and contraction. The water in a standpipe seldom remains at the same elevation for any length of time, and as the water rises or falls, so the pressure increases or decreases, and with an increase of pressure, expansion takes place.

The failure of most washes applied to the interior of concrete tanks the size of ours is due, I believe, to the fact that they soon become hard and brittle as the concrete itself, and expansion and contraction soon cracks the wash with the concrete.

From the above data it was apparent to me that the only method to insure any permanency in waterproofing was in an elastic membrane of some description. I next got in touch with the engineers of some of the leading companies building concrete standpipes and it was agreed that elastic membrane was the proper treatment and that such a method had been successfully tried out in the tank at Westerly, R. I., which tank is nearly as large as ours and built by the same contractors. I learned that Bird & Sons, of Walpole, Mass., did the waterproofing at Westerly, and after going over the matter carefully with them, the commissioners signed the contract to waterproof our tank for $3 000 with a five years' guarantee.

The elastic membrane was composed of felt and cementing compound or hot asphalt, permanently elastic, built up by successive layers, the number varying according to the water pressure, forming a permanent elastic waterproof shield.

The method of applying was simple. After the tank had been emptied and cleaned it was dried out by removing the manhole cover in the bottom and the cover on the roof, creating a strong draft which dried the inside in about three days; after this the bottom of the tank and the walls as high as a man could reach were brushed with wire brushes to remove all sediment, leaving a good clean surface; next a coat of especially prepared paint was put on, leaving the surface ready to receive the first coat of hot asphalt; after the required number of coats of asphalt and felt had been applied to the bottom and for about six feet up on the walls, a raft or floating stage was built inside the tank, the manhole cover put in place and water admitted to a depth of about five feet to float the stage. The melting tanks were placed on top of the standpipe in order that the hot asphalt could be received more quickly on the stage. About five feet per day was completed, and as the water followed the work it was thereby tested for leaks. A band of iron was placed around the inside at the top to prevent the waterproofing from ever tearing away or becoming loose. The



THE ATTLEBORO STANDPIPE, SHOWING THE BRICK COVERING.

Attleboro standpipe received five layers of felt and six of compound. This process is similar to the one used for waterproofing bridges and various other structures with absolute success.

The next problem was to repair the outside of the standpipe. Patching had been tried, as read from the report of the commissioners in 1906. The patches above cited remained for several years, but for the last two winters have gradually scaled off, and as new places had started it was very evident that more patching would make only a temporary job. The question then arose how to make a permanent job.

Several contractors were interviewed and various methods advanced. The casting of more reinforced concrete around the present tank was too expensive and no assurance but what it would scale off as before. Brick seemed the most practical and inexpensive, and after putting the job out for contractors to figure, C. L. Bowen was awarded the contract to build an eight-inch brick wall around the tank, from the original tank foundation to a height of sixty feet. This was determined on for two reasons,— the contractor was afraid that cold weather would prevent going any higher, and above sixty feet the tank was in fairly good condition and would be protected for the winter. By putting on a large force of men and being favored with good weather the sixty-foot mark was reached sooner than anticipated and the second contract to build the remaining thirty-seven feet was signed, but at the seventy-five foot mark cold, windy weather put a stop to the work for the winter, but it probably will be finished in the coming spring.

An air space was left between the concrete and brick to help maintain, as nearly as possible, uniform temperature in the reinforced concrete. Also openings were left in the brickwork, near the bottom, so that the water may run out, in case a leak should ever develop through the waterproofing, thereby saving the brickwork from possible injury and also to give early warning of such leak.

The tank was thoroughly cleaned inside, after the waterproofing job was finished, filled with water, and has been in use since, showing no signs of leakage up to the present time.

CONCRETE STANDPIPES.

TOPICAL DISCUSSION.

[*March 10, 1915.*]

THE PRESIDENT. In approaching the subject of reinforced concrete standpipes, it may interest you to have called to your attention in a very general way the progress which has been made in this line.

We find on looking up the literature of the subject that approximately thirty standpipes at least have been built.

It is interesting to note the period of greatest activity. The first standpipe of this sort of which we find mention is one built in Little Falls, N. J., a tank 10 ft. in diameter and 43 ft. in height, built by the East Jersey Company in 1899; in 1903, two more, one at Milford, Ohio, and another at Fort Revere, Hull. In 1904 was built the tank at Attleboro; in 1906, at Waltham; in 1908, two more, one at Bondsville, Mass., and the other in Mexico; in 1909, three; in 1910, four; in 1911, ten; in 1912, four; in 1913, seven; and in 1914, three.

When the subject was first broached, engineers generally had a good deal of anxiety as to what would be the ultimate experience with these tanks, particularly as the heights increased; in other words, as the pressures which they had to meet increased. In the period since 1899 considerable experience has been had with the tanks which have been built; therefore it seems a fitting and live subject for this Association to discuss.

We are fortunate in having with us to-day a number of men who have built the tanks, a number of men who have been responsible for their building, and men who are operating those tanks. So that we should hear the different points of view with regard to them expressed and fully discussed.

MR. H. B. ANDREWS.* We have built about seventeen of the thirty or more concrete reservoirs that have been built, all in New

* Engineer, Simpson Bros. Corporation.

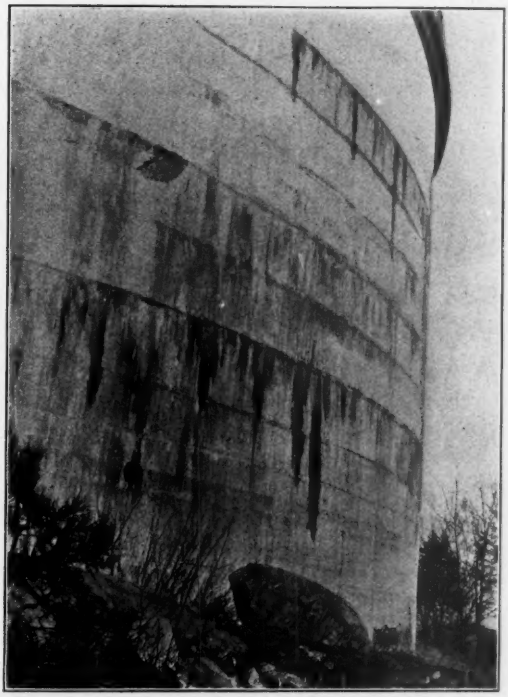


FIG. 1.

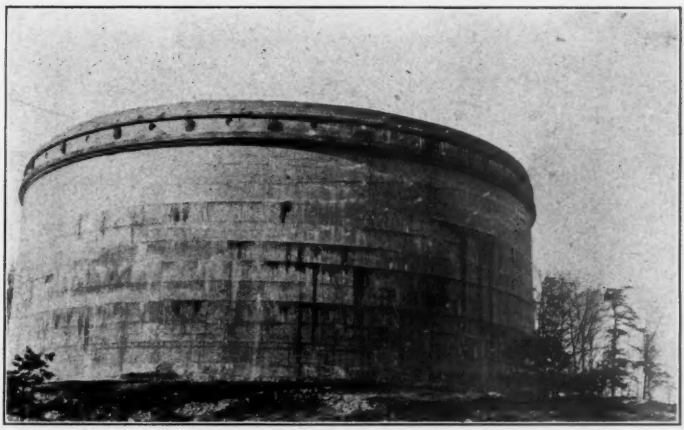
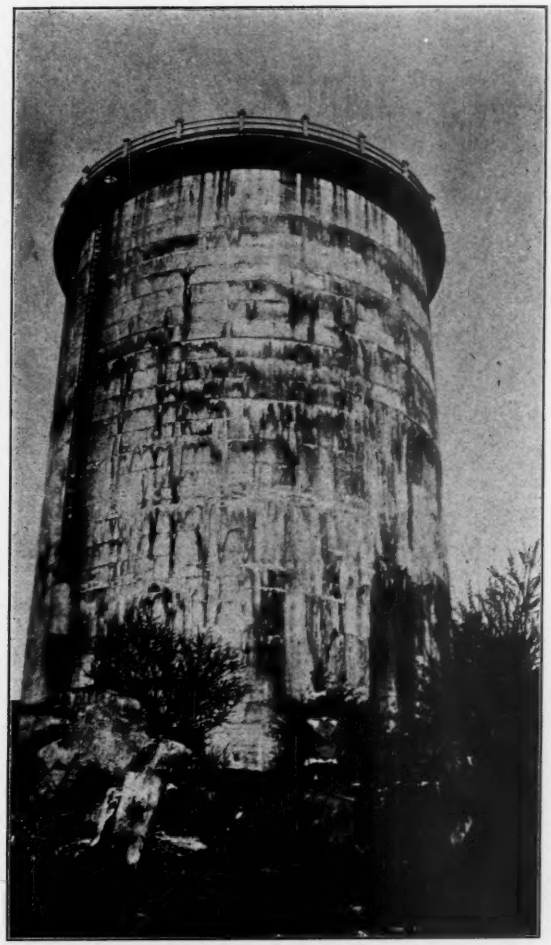


FIG. 2.
THE STANDPIPE AT WALTHAM, MASS.



THE STANDPIPE AT MANCHESTER, MASS.

England. We have had our difficulties in some cases, and in other cases we have not had any difficulty.

We commenced our work by building the Waltham reservoir in 1904. (Plate VIII.) We had nothing to say in regard to the design of this reservoir. It was designed by the city engineer of Waltham, and the plans were gone over by Mr. Worcester, consulting engineer. There was not very much precedent at that time for the design of reinforced concrete standpipes. The proportion of concrete was 1:2:4, and the aggregate was especially selected to make it waterproof. The reservoir was built in successive lifts of about three feet. We anticipated some trouble at the joints if special precautions were not taken to prevent it. The joints were cleaned as we went up, and recesses were made in the preceding day's work by putting in strips of wood entirely round the tank to form a slot to engage the next day's work. The reservoir was plastered on the inside with one-half or three-fourths inch plaster, and in the top half was painted with a neat cement wash. We found after the water was turned into the reservoir that the concrete in itself was not entirely waterproof and that the joints leaked to a certain extent. We decided to make some changes in the next reservoir we built.

The next reservoir we built at Manchester, Mass. (Plate IX). This reservoir was 50 ft. in diameter and 72 ft. in height. We increased the richness of the mix to 1:1.5:3; we also increased the amount of the reinforcement between base and walls. We plastered this reservoir also on the inside, and when it was filled there was but very little leakage. Subsequently two or three cracks developed on the south side of the reservoir, caused by the unequal expansion due to the rigidity of the base and the expansion of its circular shell above, which caused a shear in the concrete and opened up a joint perhaps 30 ft. in length. That was repaired by putting a lead lining over that joint. But the continued change in expansion, due to the filling and the refilling of the tank and the change in the temperature, caused that joint to open again and some water to get in it, so that the leakage reappeared. This reservoir has been repaired by lining it with asphalt and felt over a certain extent of it, so that no leakage appears there now. But it was found necessary to increase the amount and length of

DATA ON REINFORCED

Location.	Inside Diam. in Feet.	Height of Tank in Feet (Shell).	Depth of Water in Feet.	Capacity in Gallons.	Date Constructed.	Total Cost.
Little Falls, N. J.[1]	10	43	43	25 260	1899	
Milford, Ohio	14	81	78	93 000	1903	
Fort Revere, Hull, Mass.[2]	20	50	49 ±	118 000	1903	$4 000[3]
Attleboro, Mass.	50	102	100	1 500 000	1904	35 000
Waltham, Mass.	100	37	35 ±	2 000 000	1906	26 000
Bondsville, Mass.	70	20	20	576 000	1908	
Empalme, Senora, Mex.	30	90	90	475 000	1908	
New Haven, Conn.	50	25		375 000	1908	
Lenoir, N. C.				500 000	1908	
Bridgewater, Mass.	30	78	78	413 000	1909	
Manchester, Mass.	50	72	70	1 060 000	1909	30 291
Lisbon Falls, Me.	50	62	60	910 600	1909	19 288
Westerly, R. I.	40	70	70	650 000	1910	18 722
Rockland, Mass.	46	104	102	1 300 000	1910	36 300
Cherry Valley, Mass.	40	21′ 4″	20′ 9″	195 000	1910	4 976[4]
Rochdale, Mass.	40	21′ 4″	20′ 9″	195 000	1910	4 976[4]
Kensington, Conn.	50	21	20′ 5″ ±	300 000	1910	5 100[5]
Key West, Fla.	78	40		1 500 000	1911	24 950[6]
Laconia, N. H.	28	46′ 1″	43′ 6″	200 000	1911	6 575[7]
Brockton, Mass.	160 each	26′ 6″	25	3 760 000 each	1911	82 200[8]
Western, Mass.[9]	50	38	36	441 000	1911	6 706[4]
Waverley, Ohio	16	82	80	120 000	1911	4 500
Ashland, Mass.	40	32′ 2″	31′ 8″	298 000	1911	5 810[4]
Northbridge, Mass.	25	28	27	90 000	1911	2 899[4]
Suffern, N. Y.	69	20′ 6″[10]	19′ 9″	559 000	1911	6 500
Lexington, Mass.	30	104′ 6″	104	550 000	1912	19 900
Belton, Tex.	24	75	75	254 000	1912	6 000
Winchester, Mass.	29	43′ 6″	40′ 6″	200 000	1912	8 000
Penetanguishene, Ont., Can.	50	21	20′ 5″ ±	300 000	1912	
Austin, Minn.	40	29′ 8″	29	300 000	1912	
Topsham, Me.	97	47′ 9″	46′ 3″	2 500 000	1913	38 000
Fulton, N. Y.	40	100′ 4″	100	940 000	1913	24 335
San Francisco, Cal.	60	35′ 10″	35′ 5″ ±	750 000	1913	
St. Louis, Mo.	153′ 6″[11]	33	31′	4 250 000	1913	51 850
Chelmsford, Mass.	40	20	20	188 000	1913	5 180[4]
West Falmouth, Mass.	30	45	45	238 000	1913	9 800[4]
Woonsocket, R. I.	79	45	44	1 600 000	1913	23 514[4]
Sioux City, Ind.	142	33′ 1″	32′ 1″		1913	
Duxbury, Mass.	40	35	35	328 000	1914	7 115[4]
Webster, Mass.[12]	46	20	20	249 000	1914	5 260
Jamestown, R. I.	35	50	49	350 000	1914	10 010[4]
Halifax, N. S.	160	29		3 250 000	1914	56 000

[1] Inside filter house. [2] Inside concrete, brick tower. [3] Excluding tower. [4] Contract price.
[5] Construction only. [6] Including roof, $5 000. [7] Excluding foundation. [8] Two tanks, cost of both.

CONCRETE STANDPIPES.

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H. B. Andrews	Simpson Bros. Corporation	
H. B. Andrews	Simpson Bros. Corporation	
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F. Fuller		
H. B. Andrews	Simpson Bros. Corporation	
F. W. W. Doane	Standard Const. Co.	Canadian Engr., March 25, 1915, p. 381

[9] Partly below ground surface. [10] Lower half is constructed below ground. Earth backing for retaining wall. [11] At top, 23'; below top diameter=151' 6". [12] Protected by earth bank.

vertical reinforcement as cracks appeared at the end of the rod which joined the floor to the wall.

This we did in the succeeding tank which we built at Lisbon Falls. (Plate X.) That tank also was built with 1:1:2 mix, and plastered, and it has not shown any leakage. That was built in 1909. I saw it last summer, and there was no water that leaked out through the tank and reached the ground. There was but one little spot about half an inch in depth and the size of your hand where the frost had scaled off the surface. We found some vertical cracks in the reservoir at Manchester in the plastering and decided that the concrete was not thick enough. That is, there must be thickness enough of concrete to resist the tension in the tank, or else the tank will crack.

In the one we built at Rockland (Plate XI) we built the tank with concrete walls thick enough and strong enough to resist all tension. We did not plaster the tank. The forms used consisted of movable wooden sections connected by a bolt extending to 1½ in. from surface fitted with threaded sleeves. Into these threaded sleeves were screwed tap bolts fastening the forms together, and these tap bolts were later removed and the holes plugged for the 1½ in. depth. We found that after the pressure had exceeded some 60 or 70 ft. of water there was enough pressure to force the water through at the plugs that we put in. There was a little channel under the bolts caused by settlement of concrete, and the water filtered through there to the outside plug and caused some trouble through the freezing of water near the surface, causing the scaling off of quite an area. We took out some of those bolts and replugged the holes, and had no further trouble in that respect. We had had some trouble with the joints in the first reservoir built. The Rockland reservoir was 104 ft. in height, and the Lexington reservoir was the same.

The later reservoirs that we have built have not exceeded 50 or 60 ft. in height. In those we used a 1 : 1 : 2 mix of cement, and we find that is impervious to water. We have had no leakage through the concrete whatever, and we have found that that proportion of cement is as good waterproofing material as we can put in concrete. We find that it also increases the strength of the concrete against cracking. The only trouble we have now —

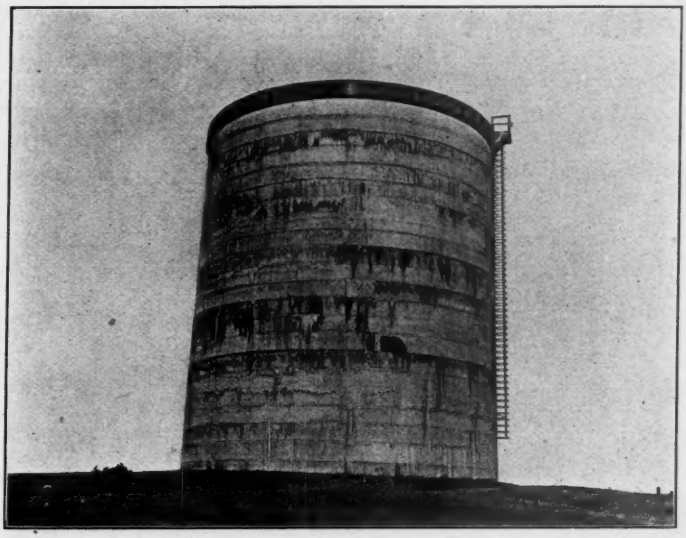


FIG. 1.
THE STANDPIPE AT LISBON FALLS, ME.

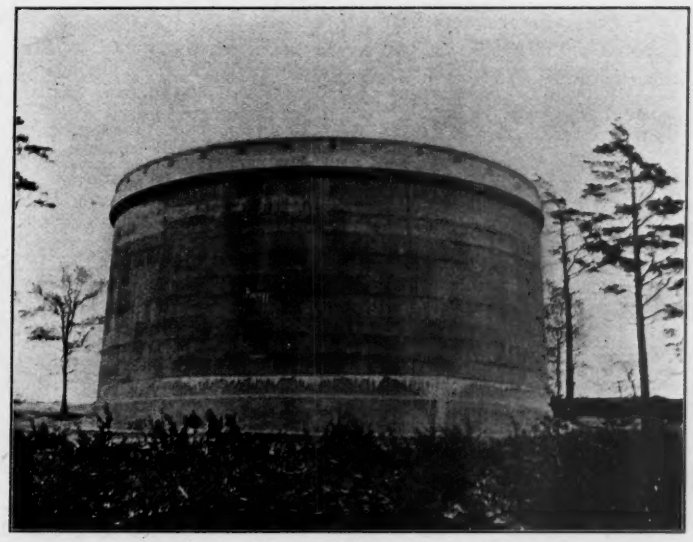


FIG. 2.
THE STANDPIPE AT WOONSOCKET, R. I.

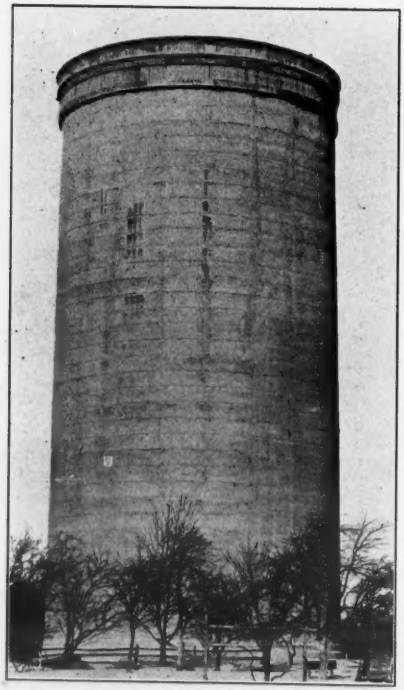


FIG. 1.
THE STANDPIPE AT ROCKLAND, MASS.

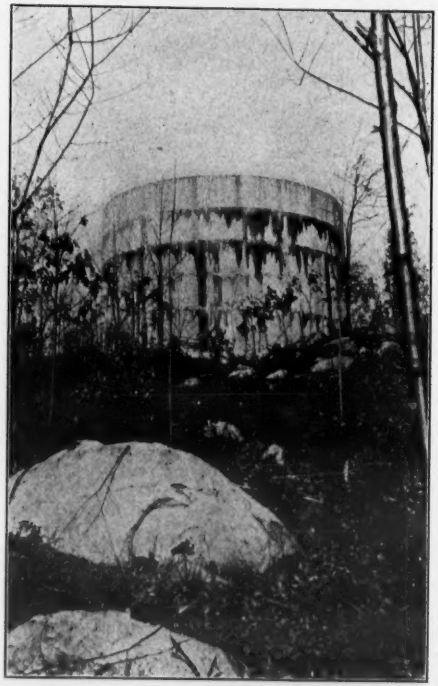


FIG. 2.
THE ASHLAND, MASS., STANDPIPE. MARCH, 1915.

PLATE XI.
N. E. W. W. ASSOCIATION.
VOL. XXIX.
TOPICAL DISCUSSION.
STANDPIPES.

and we have had very little of that — is in the joints. Since we built our first reservoirs we have made some experiments on the protection of joints that have worked out very well.

I do not think we have had any leakage whatever in the standpipe at Winchester. (Plates XII, XIII.) On the one at West Falmouth there has been no leakage. On the one at Woonsocket (Plate X), there was a little efflorescence that showed around the joints when the tank was first built; it has now disappeared, and I do not think there is any there now. The one that was built at Jamestown, R. I. (Plate XIV), shows some seepage, according to the picture. There is a peculiar thing about that. I was down there three months after the tank was filled this winter. The superintendent of the water works, Mr. Kent, said there was no leakage of water whatever, and I went over there, and as I approached the tank on the side from which the photograph was taken I could see absolutely no seepage, but there was a little seepage on the other side. Mr. Kent says these spots show more prominently on days when the humidity is high.

In these reservoirs up to 50 or 60 ft. in height we have had no trouble with surface damage by the frost,— only in three reservoirs that I know of. That is the Rockland reservoir, the one that was built in Manchester, and the one that was built at Lexington — for the first 30 or 35 ft. in height, above that no trouble.

Mr. Bertram Brewer.* I have not very much to add to what has already been said. Our standpipe is of considerable interest because it is one of the older ones. This summer it will be nine years old.

I think there is one peculiarity about our attitude regarding the design and construction of the Waltham tank. (Plate VIII.) From the outset we rather anticipated that it would be impossible to get an absolutely watertight tank, and we so told the city government and informed them that it would be well, we thought, to spend the money for the structure, but that they must expect some seepage and possibly some leakage. We did not think, however, that the seepage or leakage would endanger the stability of the structure. Now, with that sort of an article of faith, you can see that the attitude of mind, or rather our attitude of mind,

* City Engineer, Waltham, Mass.

is somewhat different from that of those gentlemen who thought they were going to get a watertight tank.

The result has been this. The first year or two there was very little seepage; some at the joints, and a good deal of efflorescence and some stalactite formation on the outside of the wall. After being in use for a year or two the seepage began to increase considerably, so that when the tank was full (it is 35 ft. high) a considerable portion of it has been and is quite wet. It never has leaked or seeped sufficiently to cause the water to run down the sides to any extent. It has mostly evaporated before it got to the bottom.

After the first two years this seepage has continued about the same every year. If you went out to Waltham at this time of day, when the tank is full, you would see a large portion of the wall, perhaps a quarter, wet from seepage, mostly from the joints.

The question is vital as to whether this seepage has endangered the tank enough to affect its stability. We do not believe it has. On the lower two feet of the tank, and in one spot higher up, there has been some frost action, so that in places pieces of the concrete have spalled off. In two places around the base of the tank there are small areas where the spalling has reached a depth of three inches. I think that on its ninth birthday it will need a little repairing.

An attempt was made the summer before last to do some repairing on the inside, something along the line of what has been suggested to-day, in the way of applying a waterproof film to the interior. The work was done by a local contractor, and no engineer was consulted in connection with it. As I understand it, it cost something like six or seven hundred dollars. A brush coat of hot tar was painted upon the interior wall. This attempt at waterproofing does not appear to have reduced the seepage at all.

I think I have made it perfectly clear to you, gentlemen, that we do not consider that to-day the stability or soundness of this structure is at all at stake. Up to now the tank has not needed any repairs. At the present time it needs some slight repairs, as has been indicated.

MR. RAYMOND C. ALLEN.* My experience, like that of Mr.

* Civil Engineer, Manchester, Mass.

FIG. 1.

THE STANDPIPE AT WINCHESTER, MASS.

FIG. 2.

THE STANDPIPE FOR THE SUMMER CAMP OF THE MASSACHUSETTS INSTITUTE OF TECHNOLOGY, AT GARDNER LAKE, ME.

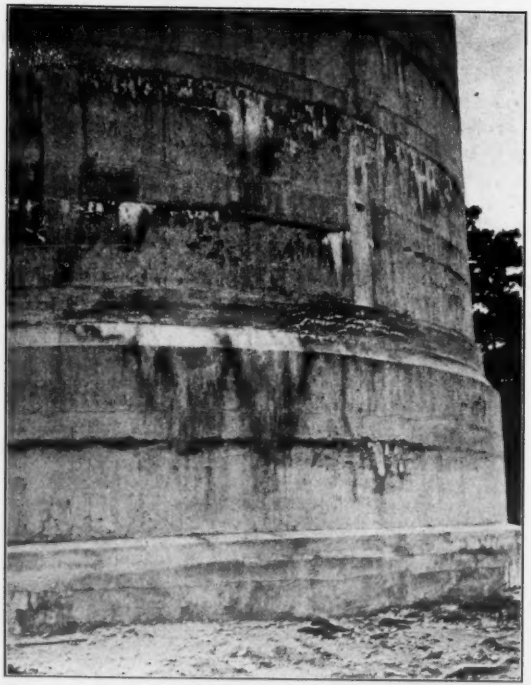


FIG. 1.

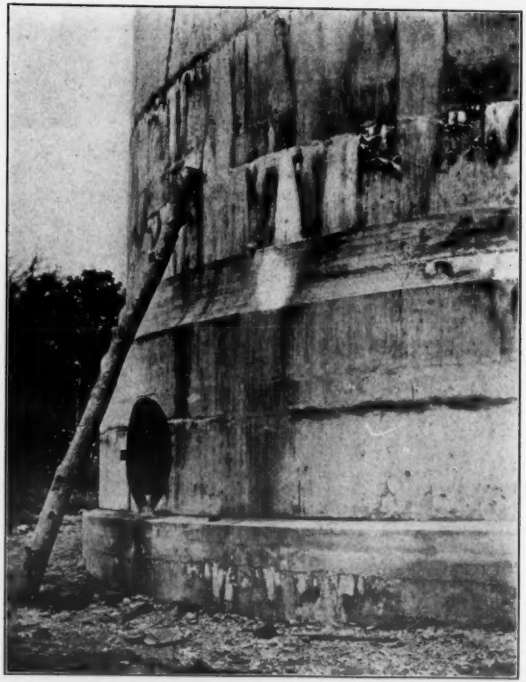


FIG. 2.

THE WINCHESTER, MASS., STANDPIPE. MARCH, 1915.

Brewer, has been limited entirely to the standpipe with which I have been connected, although, like every one who has had any part in the responsibility for a concrete standpipe, I have made considerable study and observation of others.

The standpipe at Manchester (Plate IX) was built very carefully, and of the best materials. Shortly after it was filled a fracture appeared at the first joint at the base, which in a short time extended a length of about 30 ft. Through this fracture the water in a short time came in a sheet, over a length of from 10 to 12 ft., and trickled through at other points. One other leak of quite considerable proportions appeared about 15 or 16 ft. up. This was not as wide as the other, but similar. There was no other leak, but there was a seepage at many of the joints.

We tried first a cement coating. We found it unsuccessful. Then the two joints which were in the worst condition were repaired by putting a layer of lead with tar over them, as Mr. Andrews has described. This sealed these joints until a year or two ago, when the pressure forced the water into that crack to the extent of fracture, and the leaks again appeared.

Those two leaks have been repaired about a year ago by a similar waterproofing process to that, a description of which you have heard to-day, and the standpipe has been protected within by some further construction against ice and other damage.

I think there are one or two points that have been brought out by Mr. McKenzie with which my experience and observation on the standpipe at Manchester coincide. I have noticed, first, that the greatest amount of seepage and of leaks has occurred on the south and west sides, where the expansion seems to be most unequal. I have also noticed that as from time to time the standpipe is lowered entirely and filled again, the successive fillings have produced new points of seepage. At all events they act a little differently, and are cumulative in their effect. Thus each time a standpipe is emptied and filled, I believe that a slight increase in seepage for a time at least takes place.

We at first feared the action of frost, — although our fears were somewhat allayed at the time by others who had built concrete standpipes. Last year we had a piece about eight feet square thrown off at about the location of the upper leak to which I have

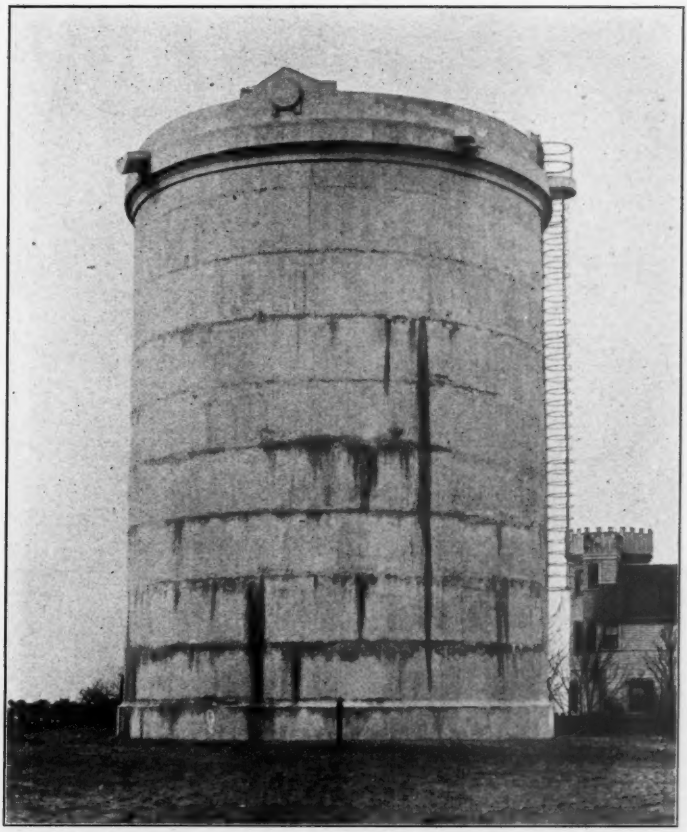
before referred. This was clearly the action of frost, and the action of it upon the concrete was to completely disintegrate it. It was just so much sand. That was true upon some portions of the base upon which the water had been constantly running and freezing, but behind the reinforcement, where no movement of concrete had taken place, there was no disintegration. It was only in the outer shell where disintegration took place or any damage appeared in the concrete. I think Mr. Andrews' observation will bear me out in that.

I have come to the conclusion, myself, that such standpipes as are over about 50 ft. in height should be entirely waterproofed on the inside by some preparation similar to those described here. I will go a little further and say that I feel that the outside of the tank itself should be protected from the elements. For while the greatest danger from frost comes from the freezing of seepage through the structure, I believe that in time at least the action of snow and rain and the water coming down from the roof will have the same effect as it will when a larger amount of water comes through from the inside in the form of seepage.

The appearance of the outside of the standpipe is due to efflorescence and not to leakage. On the right of the picture and about one third up from the the bottom of the standpipe may be seen the outline of a patch put on to the standpipe about a year and a half ago to replace the portion thrown off by the frost and referred to in my discussion. The only leakage in the pipe at the present time is at or near this patch, and this leakage is a drop at a time at two points, somewhat similar to the drip from a faucet which is not quite tight.

MR. FRANCIS W. DEAN.* I was probably more responsible than anybody else for having a reinforced concrete standpipe built at Lexington. (Plates XV and XVI.) I was on the Board of Water and Sewer Commissioners at that time, and it became necessary to build a standpipe. I felt quite strongly that it ought to be of concrete rather than of steel, and I succeeded in influencing my fellow members to that belief. My idea was to have something permanent and something that was more attractive-looking on the landscape than steel.

* Mechanical Engineer, Boston, Mass.



THE STANDPIPE AT JAMESTOWN, R. I. MARCH, 1915.

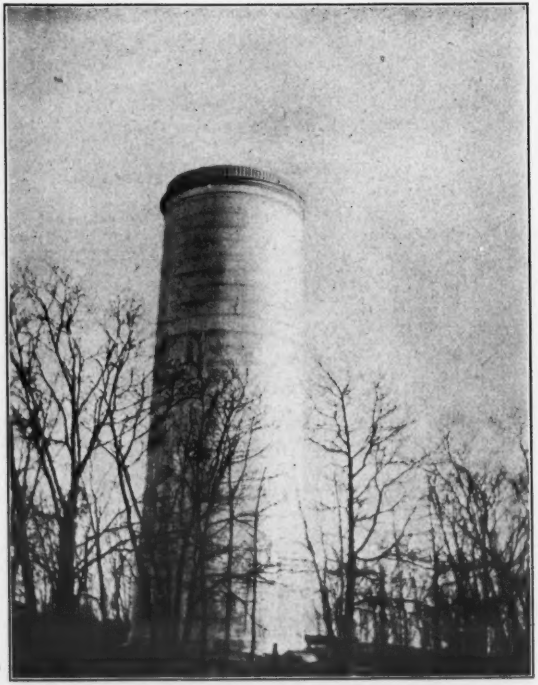


FIG. 1.
THE STANDPIPE AT LEXINGTON, MASS.

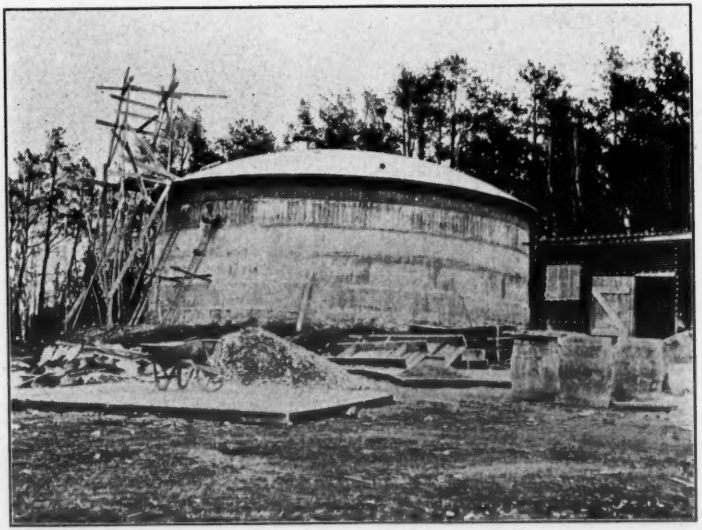


FIG. 2.
THE STANDPIPE AT CHELMSFORD.

I think as far as the latter feature is concerned it was successful, and in general the standpipe has been satisfactory. I should judge that it has been fully as satisfactory as any standpipe of that kind.

If I remember rightly, an effort was made to prevent leakage in the first place by pasting canvas on the inside, using marine glue. It was supposed not to dissolve, but some mouths later it was found that most of the canvas was at the bottom of the standpipe.

Furthermore, the leakage was confined to quite a small area, and chiefly on one side, about 25 ft. from the bottom, as I remember it. Afterwards, when cold weather came, a small part of it spalled off, and that has been repaired. I believe the leakage now is almost nothing.

In advising this to the members of the Board I of course looked up the matter of reinforced concrete standpipes, and had a talk with Mr. Brewer, who I knew had been through a good deal of the trouble. He strongly advised it, I felt perfectly safe in advocating it, and I do not think that so far any mistake of importance has been manifest.

Mr. William S. Johnson.* My experience has been limited to rather low tanks, and unless I change my opinion very materially, my future experience will have the same limitations. None of the tanks which I have built is over 40 ft. in height, but they all leak more or less. There has been no spalling off of the outside surface, and the actual quantity of water passing through the concrete is very small, but it is enough to make the tanks unsightly, and, of course, arouses a certain suspicion as to the safety of the structure in the minds of those who know little about these matters.

I am convinced that high standpipes are much better built of steel than of concrete. To be sure, the steel tanks are unsightly, but so are concrete structures, discolored by leakage. The repairs on a steel tank are expensive and annoying, but they cannot be more so than the repairs to concrete tanks which have been described in such detail here to-day. As to the durability, the evidence indicates that concrete tanks are far from indestructible,

* Civil Engineer, Boston, Mass.

and there is much uncertainty as to how long they will really last.

Until some better method of designing and constructing concrete tanks is found, it seems to me very unwise to install them to hold more than 50 ft. of water.

MR. SIMPSON.* As Mr. Dean said, there are three joints that scaled off of the Lexington standpipe which were fixed with canvas. We are absolutely ready to build tanks up to 110 or 115 ft. high, and we can build them perfectly, but not without an interior lining.

I want to ask Mr. Allen if I am correct in stating that they have an exceptional condition down there, in which they fill their standpipes at four o'clock in the summer months, and fill up to something like 60 ft. of water, and then stop pumping, and it goes down to 30 or 45 ft. before the end of the afternoon, thus getting every day in the summer a height of 25 ft. in the afternoon and 70 or thereabouts the next morning. This was one of the things that led us to say that the walls of a concrete standpipe must be heavy enough to have no movement whatever.

MR. CHARLES W. SHERMAN † (*by letter*). I have recently had opportunity to make a personal examination of the present condition of the Lexington and Winchester standpipes and have taken some photographs illustrating this condition, which are shown in Plates XVI and XIII.

The Lexington standpipe, as might be expected from its great height, has been more affected by leakage than the one at Winchester. It is particularly to be noted that the real damage to the structure appears to have occurred mainly between 10 and 20 ft. above the bottom, rather than at the joint between the bottom and sides of the structure, and that the damage is not confined to the south side, but appears also on the north side as well as on the east and west. There are four particularly noticeable spots of damage, corresponding roughly to the four cardinal points of the compass, and all of the same general character, as shown by the accompanying photographs. In these spots the concrete outside of the reinforcement appears to have been bulged out by frost a maximum distance of perhaps six or eight inches and has the appearance of being nearly ready to spall off. The photographs

* Of Simpson Bros. Corporation.

† Of Metcalf & Eddy, Engineers, Boston, Mass.

West Side. North Side. South Side.

VIEWS OF LEXINGTON, MASS., STANDPIPE, TAKEN IN MARCH, 1915.

were taken on March 20, 1915, and even on that comparatively warm day icicles extended from the cracks to the base of the standpipe. In addition to these larger damage spots, there were a considerable number of comparatively insignificant evidences of seepage, some of them as high as 40 ft. above the ground.

At Winchester, there was, at the time of my visit, no evidence of real leakage, although there were two or three damp spots. There was, however, very noticeable efflorescence at the joints between day's work, and particularly in the lower 10 ft. or so. There was some efflorescence almost to the top of the tank.

MR. STEPHEN LITCHFIELD* (*by letter*). The standpipe for the town of Lisbon, Me. (Plate X), was completed in October, 1909, and put into commission in January, 1910. The diameter is 50 ft.; the height, 62 ft. (internal dimensions); capacity, 190 600 gal.; thickness of shell at base, 20 in.; at top, 12 in.

The structure is designed on the basis of the steel reinforcement, taking all tensile stresses at a working unit stress of 12 000 lbs. per sq. in. in the steel with the standpipe full.

The structure rests on a hard-pan bottom. Floor slab is 20 in. in thickness, of 1:2:4 concrete reinforced with 3-in. No. 10 standard expanded metal. Over the concrete base or floor is a 1-in. granolithic surface 1 : 1 mortar with 2 per cent. of Medusa Compound added to the mix.

The walls are composed of 2:1.5:3 concrete. Bank gravel, screened and washed, was used in the mixture. In the top of the floor and in walls 5 per cent. of hydrated lime added to the weight of the cement was used. The entire inside perimeter of the standpipe is plastered with $\frac{1}{2}$ in. of cement mortar mixed 1:1, with 2 per cent. of Medusa Compound added to the weight of cement. The plaster to a height of 30 ft. is painted with waterproofing compound.

Forms were constructed in three sections, the lower section being transferred to the top each day, one day's work consisting of one lift or section of 30 in.; in one instance, however, two lifts were placed in one day.

Horizontal steel bars or hoops varying in size from $1\frac{3}{4}$ in. to $\frac{3}{4}$ in. were held in place by fourteen latticed steel columns.

* City Engineer, Bath, Me.

The tank is roofed with a Gustavino dome, outer covering of which is plastic slate. Dome has a rise of 8 ft.

The standpipe was designed and built by Simpson Bros. Corporation, Boston, Mass.; contract price, $19 288.

There have been no items of repair or maintenance since the work was completed.

There is more or less seepage apparent at times, which shows at joints or where one day's work ends and another begins. Many places where seepage has occurred in the past are now entirely free from it, which leads us to believe that the structure is improving with age.

We are well pleased with the standpipe and consider it as near an approach to a permanent structure as it is possible to obtain. We feel, however, that if we had made the placing of concrete continuous, or nearly so, we would have eliminated the cause of seepage. Instead of depreciation, as is the case when other materials are used in similar structures, we consider that this one is improving. As stated above, there has been no item of maintenance to date, and there is every reason to indicate that this item is practically eliminated.

Mr. Charles L. Bowker (*by letter*). The Topsham standpipe of the Brunswick and Topsham Water District (Plate XVII) is 97 ft. inside diameter, with a conical bottom, the incline from the bottom to the beginning of the wall being 3.25 ft. rise in 10 ft. The foundation rests on solid ledge and was filled with rubble masonry laid in Portland cement mortar. The wall at the base is 3 ft. thick, and at the top 16 in. The water line is 46.25 ft. from the floor; 18 in. more to the roof. The roof is a concrete slab 7 in. thick, sloping ½ in. to the foot, supported by nine concrete piers, eight of which are 18 in. in diameter, and the ninth, having an 8-in. overflow pipe imbedded in the concrete, is 24 in. in diameter. The top of each pier is cone shaped, the top being 5½ ft. in diameter and having a rise of 24 in. An iron ladder is fastened to the outside of the wall. There is no ladder inside, neither is there a manhole in the wall. The 16-in. intake pipe is imbedded in concrete and is elevated 12 in. above the floor. There is an 8-in. flush pipe connected in the gatehouse with the 8-in. overflow, operated by opening an 8-in. gate, and the opening of this pipe is about an

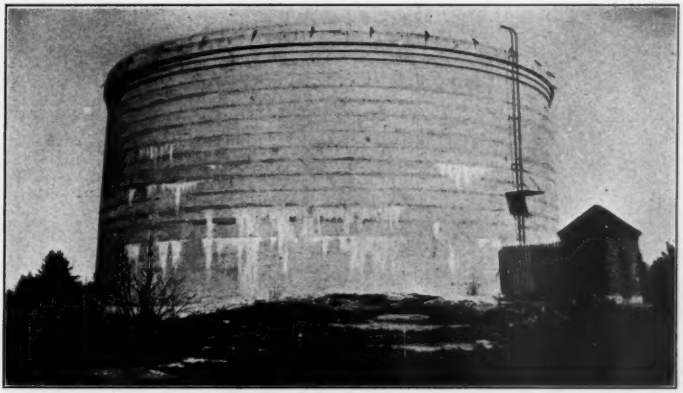


FIG. 1.

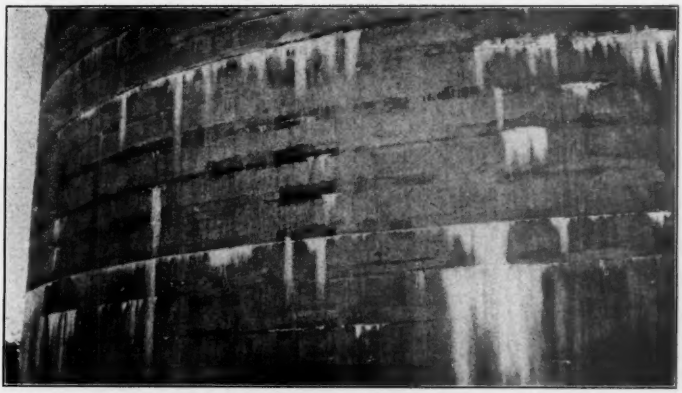


FIG. 2.
THE STANDPIPE AT TOPSHAM.

inch below the floor of the standpipe. There is a ventilator at the peak of the roof, with four ports, and numerous four-inch holes for ventilation in the wall, close to the roof. All openings are screened.

In the construction of the standpipe particular care was taken to remove all loose rock under the foundation. In the center, considerable blasting was done. The bottom of the standpipe was built in two layers, each 6 in. in thickness, after first leveling to the proper grade, the second layer being reinforced with $\frac{1}{2}$-in. round iron. The floor was troweled to a smooth surface, the finishing coat being cement mortar, 1:2 mixture, with the addition of 5 per cent. of hydrated lime, the same amount of lime also being added in the second layer of concrete.

The wall was reinforced horizontally with iron rods of various diameters, from $1\frac{1}{4}$ in. at the base to $\frac{3}{4}$ in. near the top, supported on lattice work which was built into the wall. The proportion of the concrete mixture for the wall was 1:2:3.5, with 5 per cent. of hydrated lime. A "T" iron, 6 in. by 12 in., was built in the foot of the wall, circling the standpipe, reinforcing rods anchoring this to the floor of the standpipe.

The method of building the wall was by placing the concrete in movable forms, the forms being held in place by bolting one section to the next, depending on the bolts entirely to hold the outside forms in place. An elevator was used to hoist the concrete to a runway around the wall, and the concrete was placed with wheelbarrows.

The roof was built during cold weather, and on the night it was finished it collapsed. There were various opinions as to the cause of this. During the time the concrete was being placed live steam was discharged into the standpipe to keep it warm underneath the roof. The supports for the forms were built and used as staging for the wall, and it is possible that the carpenters might have been careless in their work, perhaps weakening some place where strength was needed. Only one pier fell, the others being in use to-day. The roof was rebuilt in the spring of 1913 on exactly the same lines as before, even the reinforcing rods being straightened and used again. The roof appears perfect at this date.

All material used was subjected to the usual tests, being specified in detail in the contract.

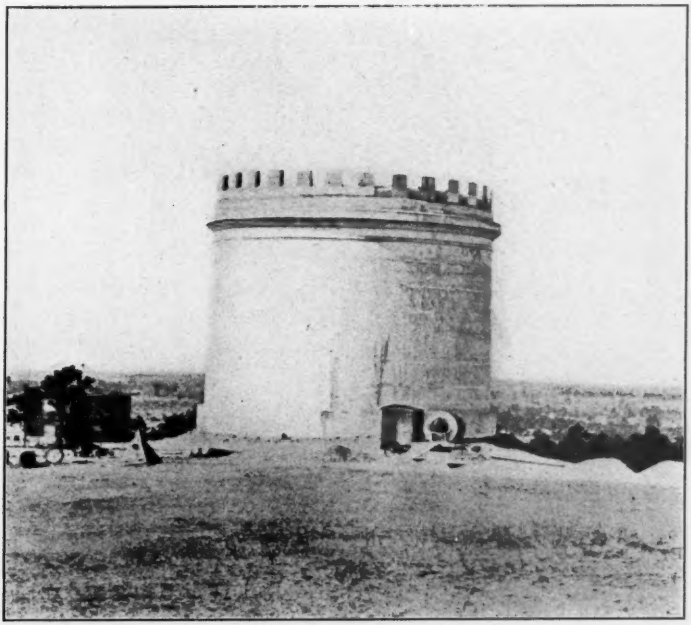
When the standpipe was first filled, various small leaks developed, on one horizontal ring in particular. To remedy this the contractors cut a recess into this joint with sharp chisels and calked it with lead wool. At this date the condition of the standpipe is very good and it is practically tight. A few damp spots appear at times, depending on the weather, but they could not be called leaks. Thus far there does not appear to be any damage to the wall from frost, and the concrete is apparently as good as when first completed.

It might be possible to construct a standpipe by building an outside wall of cement blocks, built on a batter, using them in place of a form of wood. The inside forms, being vertical, could be made of wood and their position easily and quickly changed, filling in the concrete from a spout fed by an elevator, pouring it continuously, and by this means having no dry joints to bond together. In Brunswick and Topsham there are four concrete watering troughs, each of which was built in one pouring, and there is yet one to be found that is damp on the under side. If the same principle could

DETAILED COST OF CONCRETE STANDPIPE AND FORCE MAIN TO MARCH 9, 1915.

Land	$750.00
Surveying same and looking up title	22.90
Advertising bids	2.00
Special castings, etc.	262.81
Freight	34.88
Copper conductors	68.00
Platform, total cost labor and material	41.00
Pay-rolls, work done by District	46.25
Miscellaneous expense, telephones, teams, etc.	27.56
Total amount paid contractors	*37 932.02
Engineering and inspection	1 900.00
Total, account standpipe	$41 087.42
14-inch force main, cost to date	4 387.07
Total	$45 474.49

* $38 000 less amount charged to contractors for labor and material furnished by District.



THE STANDPIPE FOR THE DUXBURY FIRE AND WATER DISTRICT.
LEAKS SHOWING ARE THE ONLY ONES THAT APPEARED. MARCH, 1915.

be carried out in building a concrete standpipe there would be no leaks. The water in the standpipe would keep the wall at an even temperature, and if the wall was built strong enough there would be little danger from expansion and contraction.

Diameter, 97 ft.; depth of water, 46 ft. 3 in.; height of wall, 47 ft. 9 in.; year built, 1912–1913; cost, $38 000.00; capacity of standpipe, 2½ million gal.; engineer for District, L. D. Thorpe, Boston, Mass.; engineer in charge of work, J. H. Caton, 3d, Manila, P. I.; contractors, Simpson Brothers Corporation, Boston, Mass.

MR. S. S. GATCH* (*by letter*). The concrete standpipe at Milford, Ohio, was erected in 1903 and is apparently in better condition to-day than when finished. After using it about two years some seepage was noticed. The water was drained out and the inside dried and coated with a cement wash. Since then there has been no seepage. The seepage was evidently caused by joints in the construction because of delaying the work at night and over Sundays.

We believe the water is kept in better condition in a concrete standpipe of small diameter than in one of any other material, but think for best results the work of construction should not be delayed from start to completion.

Basing our opinion on an experience of about twelve years, we recommend the concrete standpipe properly built on a firm foundation as better and cheaper than any other.

MR. D. C. WEBB.† My experience with concrete standpipes is confined to the design of one at Key West, Fla., in 1909. This standpipe, or cistern as it was called, is 80 ft. in diameter, 40 ft. high, and has a capacity of 1 520 000 gal.

I was detached from duty at Key West before the construction of this standpipe, so that my experience is mainly second-hand. It is sufficient, however, to point out some of the things that I shall do differently if I ever have another similar structure to design.

The standpipe was located on ground which a few years before had been filled about five feet deep with coral sand by the hydraulic process. The concrete bottom was made 18 in. thick,

*Clerk, Board of Trustees of Public Affairs, Milford, Ohio.
†Civil Engineer, United States Navy.

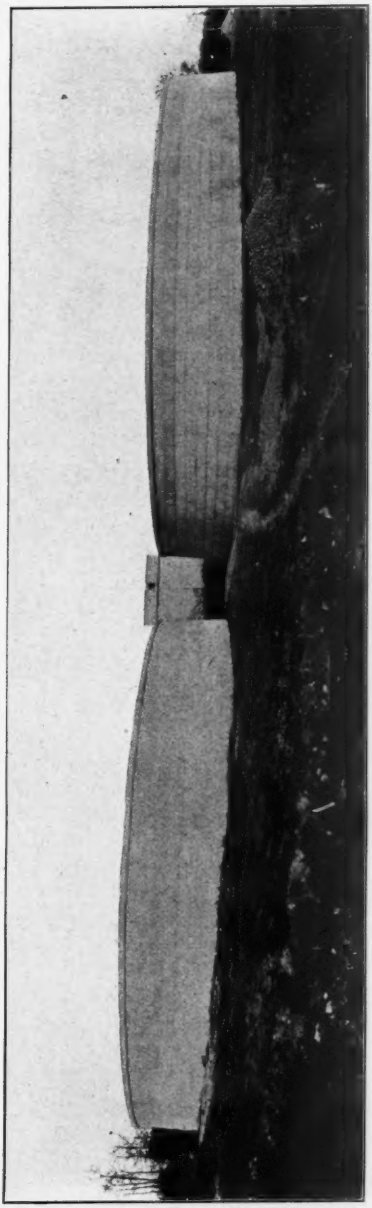
except under the standpipe wall, and was reinforced with four layers of heavy wire cloth. The upper 6 inches was of 1:2:4 concrete, the remainder of 1:3:6. No appreciable settlement was anticipated under the maximum load of less than one and one-half tons per square foot, but after completion and filling, a gradual settlement, averaging nearly 5 in., took place, the final maximum difference of level between the high and low sides being $2\frac{3}{4}$ in. This settlement apparently opened some considerable cracks in the bottom, but these seem to have been overcome with little difficulty. It probably would have been better if all the bottom concrete had been of the same mix and placed at one operation.

The standpipe wall is of 1:2:4 concrete, 12 in. thick for the lower 25 ft. The remainder is 8 in. thick. In the lower section there is a double set of reinforcing rods supported on 4-in. channels, spaced about 6 ft. 4 in. apart. These channels extended some distance into the foundation. The reinforcement in the upper section is single and supported on 2-in. angles. Splices in reinforcing rods were made by 2-ft. laps with three Crosby clips to each splice.

A proprietary waterproofing compound was mixed with the concrete under a guarantee that it would secure the desired degree of watertightness. The general opinion seems to be that the use of this material had absolutely no beneficial effect.

After the concreting was completed, but before any water had been placed in the standpipe, a crack was noticed which encircled the base of the cistern at the rigid connection with the side walls. This crack showed more on the outside than on the inside and was probably due to the contraction of the concrete in setting. When the standpipe was tested considerable leakage took place through this crack as well as through the foundation cracks previously referred to.

By the time the standpipe had been filled to a depth of 32 ft. the leakage had increased to the rate of about 6 000 gal. per day, and small leaks had appeared in the side walls near the base. The standpipe was then emptied, the large cracks covered with two layers of three-ply roofing, cemented together and to the concrete.



STANDPIPES AT BROCKTON, MASS.

The lower part of the side walls was painted with an elastic waterproofing paint.

The standpipe was then completely filled and a marked decrease in the amount of leakage was noted, but there was still considerable seepage from circumferential cracks marking the junctions of successive settings of the forms and from vertical cracks at practically every channel and angle to within 4 or 5 ft. of the top. The total leakage was now about 200 gal. per day.

Owing to the scarcity of fresh water, sea water was used for testing this standpipe. The seepage through the walls gradually lessened, as also did the remaining leaks at the base.

After a time the water was gradually lowered, the spots showing most leakage were gone over again with another coat of paint and additional protection given to the leaks in the bottom. As a result of this work the standpipe was made substantially watertight and has since remained so with practically no cost for maintenance.

The cost of the standpipe alone was $19 850. A roof was afterward placed over it at an additional cost of $4 994, making a total cost of $24 844.

ULTRA-VIOLET RAYS FOR WATER PURIFICATION.

BY M. VON RECKLINGHAUSEN, PH.D.

[*Read November 11, 1914.*]

We call *ultra-violet* the wave lengths produced by different Light sources which are shorter than the last visible violet rays. These wave-lengths have a strong bactericidal or, as we call it now, *abiotic* power.

We have to consider in relation to water purification two sources of these rays; namely, the natural source, the sun, which Duclaux calls "the cheapest disinfectant known," and the artificial sources of light, amongst which we have to consider mainly the electric arcs and sparks between metals and particularly the mercury vapor arc enclosed in fused rock crystal.

Some of the rays emitted by most light sources are distinctly favorable to life. I have in mind particularly the chlorophyll production which is going on only under the influence of daylight. Other rays, as above said, are harmful to life. It is, therefore, important in studying the influence of light on biologic phenomena to dissolve the light into its components, — that is to say, into its different wave-lengths, — and examine the effect of each one independently of any simultaneous action of any other wave-length; otherwise favorable and unfavorable actions may be superposed and thereby the image blurred.

The first to make such a biologic analysis of light was Ward, who threw the spectrum of an arc on an infected agar-plate. He found that on the violet end development of colonies was prevented, while on the red end the vitality of the germs contained on the plate was not impeded.

Another way to examine different parts of the spectrum is to use filters or screens which will allow light of certain wave-lengths only to pass. However, in this case we can only study the effect of groups of wave-lengths. I mention as particularly interesting for our case the filter consisting of colloidal silver solution in a quartz flask, which will absorb practically all the visible light and allow only a great part of the ultra-violet to pass.

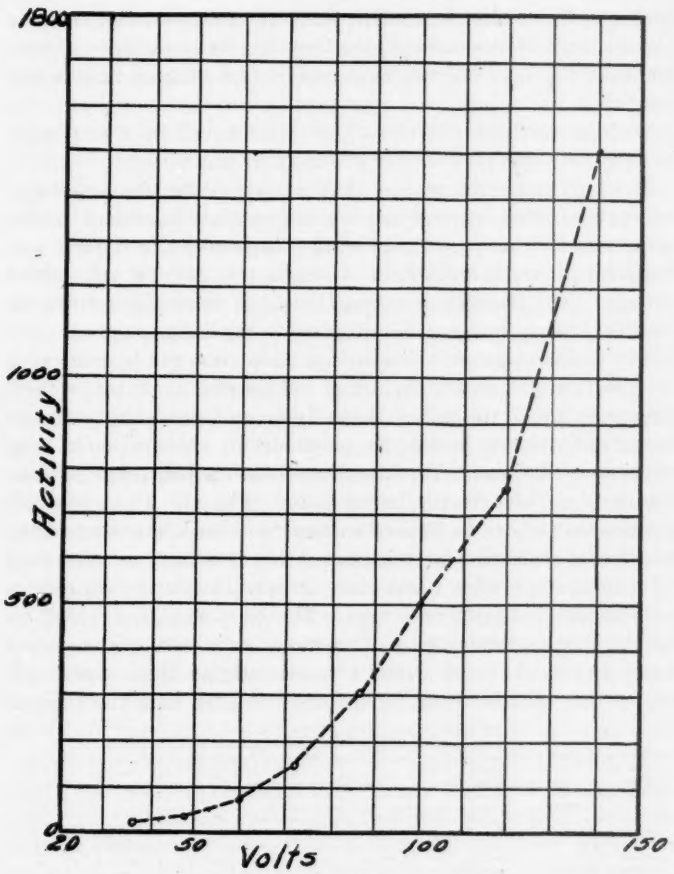


FIG. 1.

MEASURE OF ULTRA-VIOLET RAY ACTIVITY AT DIFFERENT VOLTAGES (TEMPERATURES) OF A QUARTZ LAMP.

Bang, one of Finsen's pupils, analyzed the spectrum as to its abiotic power. He found that wave-lengths of about .3μ are abiotic, while shorter wave-lengths were less powerful. In the work which Henri, Helbronner, and I carried on in Paris at the

Sorbonne University, and which forms the basis of this paper, we found that this does not hold true, but that it seems to be a strict law that the rays are the more abiotic the shorter their wave-length.

We can conclude, therefore, that a lamp will be the stronger in its abiotic effect, the richer it is in short wave-lengths.

The only industrial source of these rays is the mercury vapor quartz lamp, that is, a mercury arc enclosed in a fused rock-crystal tube. Such a lamp is a very simple instrument to handle, and burns on the usual distribution voltages, 110, 220, 500 volts direct current. On alternating-current lines the current must first be rectified in the usual way before going to the lamps.

The temperature at which such a lamp runs can be controlled by insertion of a proper amount of ballast resistance, by properly dimensioning of the tubes themselves, and particularly by removal of the excess heat at the electrodes by the creation of large electrode containers. We found that such a lamp will produce the more ultra-violet the hotter it is. (Fig. 1.) Of course this temperature has to be limited so that the heat will not affect the material of which the lamp is made; that is to say, we must keep the temperature below where the quartz will begin to desintegrate and become opaque to the rays. The temperature at which we obtain a rich production of ultra-violet rays during a period of many thousand hours without much falling off is about 700 deg. cent.; that is to say, considerably higher than the temper-

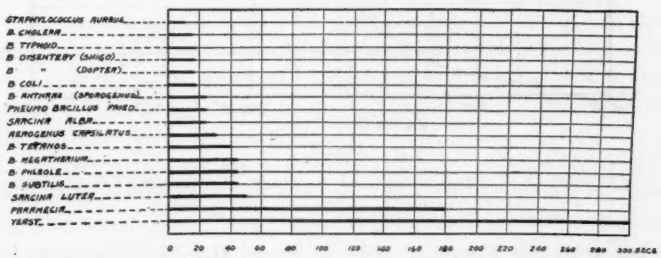


FIG. 2.

SECONDS NECESSARY TO KILL DIFFERENT TYPES OF GERMS AT 200 MILLIMETERS FROM A QUARTZ LAMP BURNING AT 66 VOLTS, 3.5 AMPERES.

ature of the water which we want to treat. It is evident, therefore, that the water must not come into direct contact with the luminous part of the lamp, so as not to reduce this favorable temperature, quite aside from other inconveniences created thereby. The way one proceeds is to burn the lamps above the water or in submerged chambers made of quartz, as will be shown later on.

We found in our experiments — and many others have confirmed — that germs vary in their resistivity against ultra-violet rays much less than in their resistivity against heat and chemicals, where some types show perhaps twenty times as much resistance as others. The table (Fig. 2) shows the relative resistivities of different types of germs.

Practically any solid substance which is opaque to visible light is also opaque to ultra-violet light. However, only a few substances which are transparent for visible light are also transparent for ultra-violet light. I mention quartz, fluorspar, water, and some salt solutions, which if colorless are nearly as transparent as air for the same rays. However, if colloids are in solution in the water, its transparency is affected, especially if these colloids are organic and colored. Physically the best waters, therefore, for submitting to the ultra-violet rays are those without colloids or color. In addition, they must be free from any solid matter in suspension; that is to say, if originally not clear, they must be submitted to filtration before being exposed to the rays. The freeing from suspended matter is a well-known problem and the solution is known. The removal of color is perhaps somewhat more difficult but this is not of equal importance for an ultimate treatment by ultra-violet rays. We have successfully sterilized water with color up to 40 on the United States scale. As to very finely divided mineral suspension, which ordinary filtration will often not remove, it acts, I think, like color in solution; that is to say, somewhat handicapping but not impeding the successful treatment by the rays. In practice, waters have been sterilized having turbidities up to 20 parts per million.

We must give the rays a chance to strike the germ during its passage through the illuminated zone. Therefore any suspensions which form shadows and allow the germ to be hidden from the light will have to be removed from the water. Of course

infected suspensions will be particularly dangerous as the germs may hide inside such material and thereby be perfectly safe from attack by the rays. All we need for a successful and at the same time economic sterilization by the rays is a naturally clear or well-filtered water. The amount of light used for the sterilization will depend on the amount of color or colloidal matter and fine turbidity left in solution by the filter. A physically perfect water will demand very little illumination for its sterilization.

However, as even the best filtration allows some minute solid material to pass through into the effluent, we found it advantageous to stir the water while passing it under the light and give thereby each particle a repeated illumination. For the same purpose we also try to repeat the illumination of the entire body of water several times by either leading it several times towards the same lamp or by passing it successively under several lamps. In this way all microscopic suspensions will surely be sterilized on all sides.

The stirring of the water during its illumination is done by inserting baffle plates inside the sterilization chamber, placing them of course so that they will form only the least shadow.

The sterilizing apparatus itself consists of a tank in which the water is lead through zones which are illuminated by mercury vapor quartz lamps. As mentioned before, the source of light must not be in direct contact with the water, because its cooling effect would impair the efficiency of the quartz lamps. For the sake of economy in light, it is better to use all the light coming from the lamp. In smaller apparatus one has to make sacrifices in this, as otherwise the apparatus would become cumbersome and expensive.

Such are, in short, the principles on which the ultra-violet ray sterilizing apparatus is built.

The following will serve to show some of the different types of apparatus.

In Type B2 Sterilizer (Fig. 3) the lamp with its electrode enlargements is suspended above the water. The water is submitted twice to the lamp, due to the cone-shaped baffles. The combination of circular and up-and-down flow results in stirring of the water during its passage through the apparatus. The output is up to 120 gal. per hour.

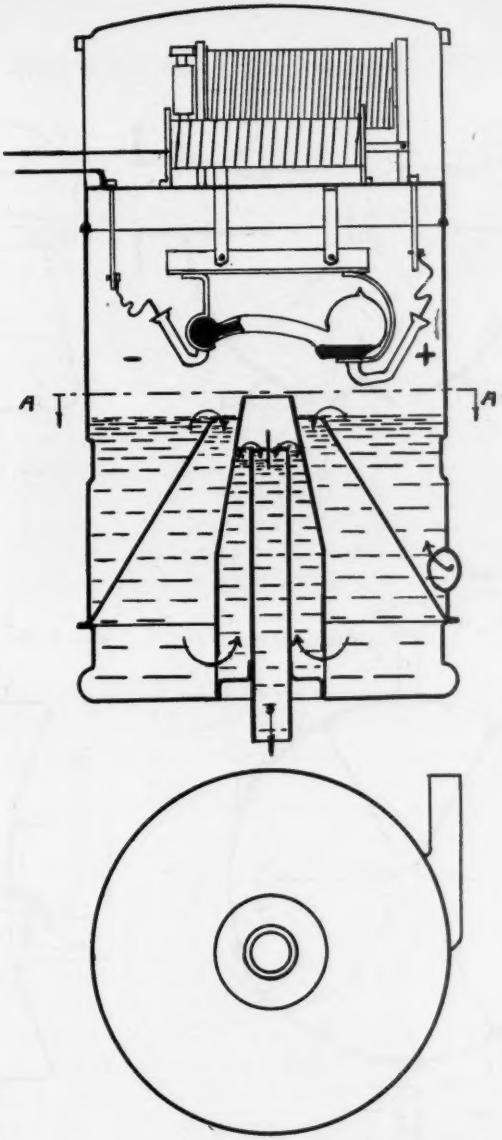


FIG. 3.

TYPE B2 WATER STERILIZER.

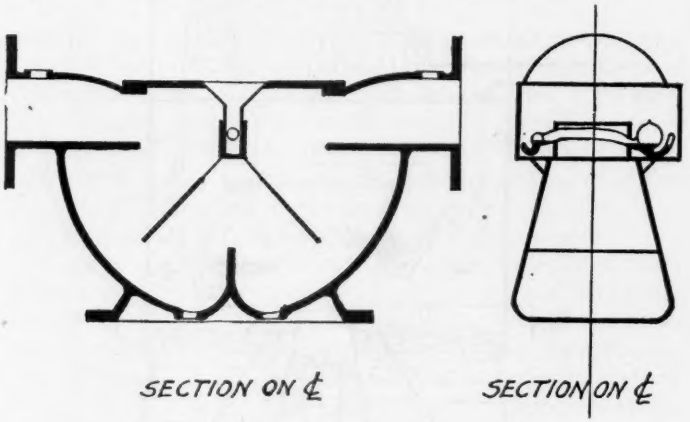


FIG. 4.
TYPE C3 WATER STERILIZER.

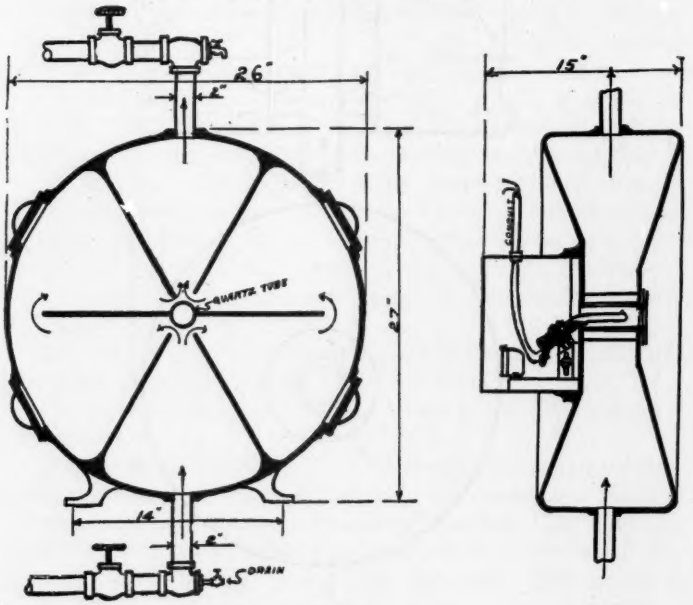


FIG. 5.
TYPE E PRESSURE APPARATUS.

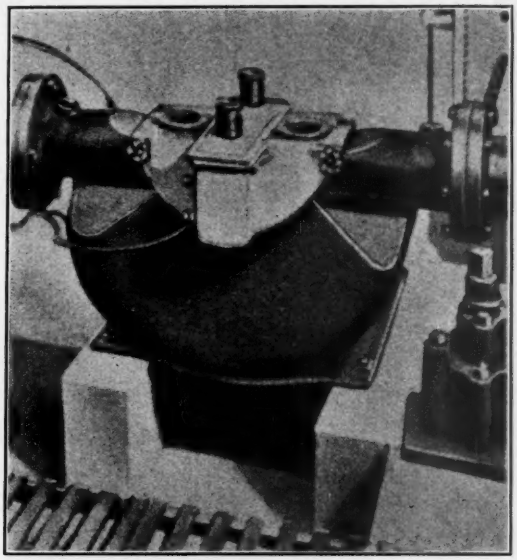


FIG. 1.
TYPE C3 WATER STERILIZER.

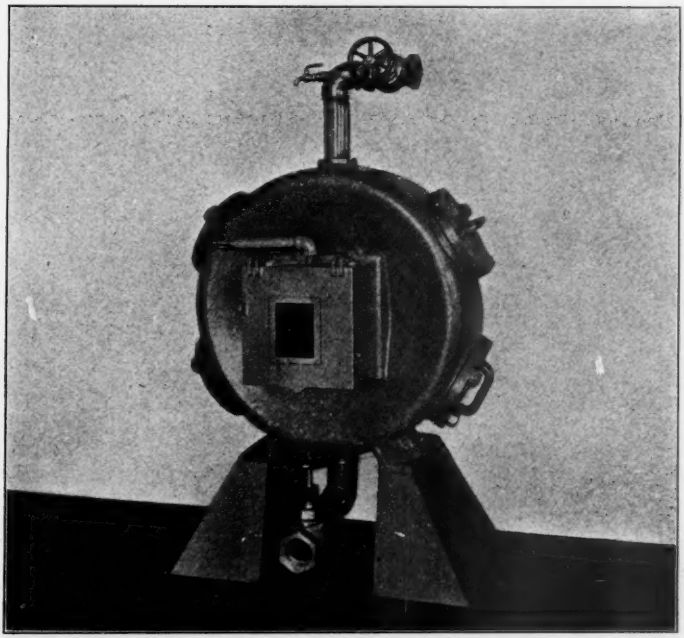


FIG. 2.
TYPE E PRESSURE STERILIZER.

In Type C3 Sterilizer (Fig. 4) the lamp with its electrode enlargements is suspended in a lamp box which has quartz windows. The water is lead three times towards the lamp. About 60 per cent. of the light of the lamp enters the water. The output is up to 6 000 gal. per hour. In Europe a good many of these apparatus are in service, some since 1910. (Plate XX, Fig. 1.)

To make use of all the light, we created the " Pistol " type lamp, which allows practically 90 per cent. of the light to enter the water. The chambers which protect the lamp from contact with the water are quartz tubes, which are inserted into the wall of the sterilizing tanks. The cumbersome electrode enlargements are kept outside the protective quartz tubes. The following types of apparatus use this method.

In Type E Pressure Sterilizer (Fig. 5 and Plate XX, Fig. 2) the

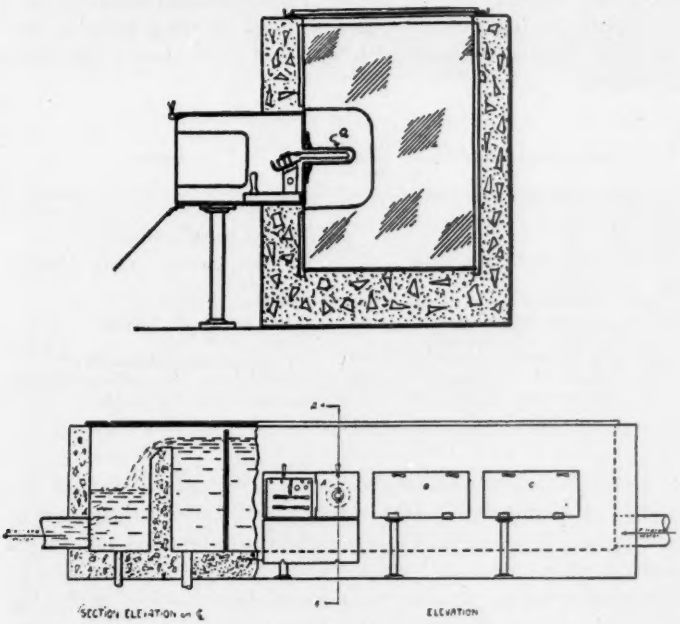


FIG. 6.
MULTIPLE LAMP FLUME.

water is brought near the lamp twice by means of the radial baffles, which also create stirring. The output is, according to the size of the lamp, 1 000, 2 000, or 3 000 gal. per hour.

In the multiple pistol lamp-equipment of the flume type (Fig. 6) the luminous zones are created by one, two, or three lamps in a group. Several such luminous zones are created, through which the water has to pass successively. Baffles are placed opposite the lamps or lamp groups, giving the necessary stirring action.

There are many different ways that lamps may be placed: I show in Plate XXI, Fig. 1, a typical arrangement of two lamps along one side of a flume. Plate XXI, Fig. 2, shows the arrangement used in Luneville (France) where ten lamps are employed.

The bacteriological results of these plants are most satisfactory, and wherever we were able to obtain the hygienic results they prove the efficiency of the system in a remarkable manner.

In the following I want to give a series of remarkable bacteriological results obtained with some of the above described apparatus.

Type.	Before Sterilization, per cc.	After Sterilization, per cc.	Operator.
B2	8 000 2 840	0 .6	Westinghouse Laboratory.
B2	80 000 Sewage bacteria	0	Glaser, Austrian Army Medical Service.
B2	11 000 Sewage bacteria	12	Burgess, London.
B2	3 740 Sewage bacteria	0	Thresh & Beale, London.
B2	35 000 Coli communis	0	Jurist, New York.
B5	273 000 Sewage bacteria	0	Westinghouse Laboratory.
B5	25 000 Bact. typhosus	0	Philadelphia Clinical Laboratory.
C3	20 000 Sewage bacteria	0	Bengal Sanit. Committee.

To obtain results such as above it is important to examine the water for its physical quality before submitting it to the light of the lamp. A water may on superficial examination not reveal floating matter; it may be perfectly clear most of the time and give good results. At other times it may contain some few floating filaments, which got into it after filtration. They will, however, reveal themselves easily to the eye of the careful observer, if he

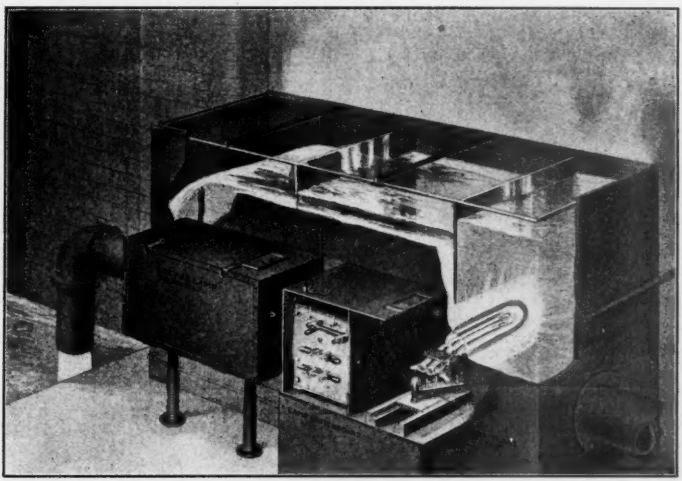


FIG. 1.
TWO-LAMP STERILIZER FLUME.
(By courtesy of the *Scientific American*.)

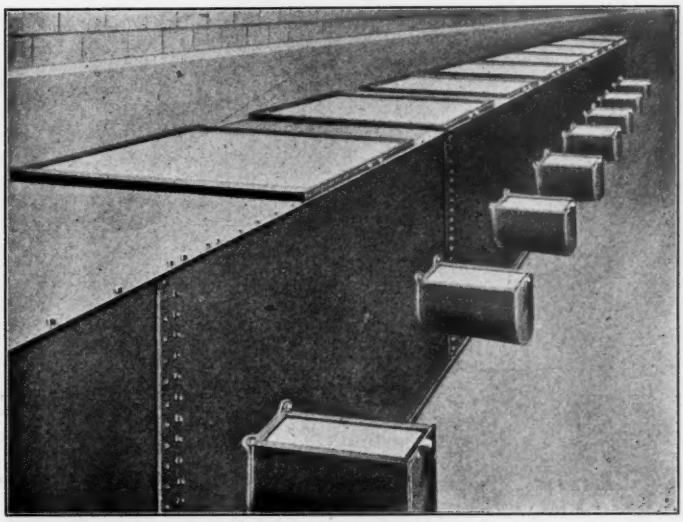


FIG. 2.
TEN-LAMP STERILIZER FLUME.

takes the pains to look at the water under a strong light (sun or arc lamp) against a dark background. In my opinion the best proof for a slight amount of floating matter is a test like the above B2 test, where 12 germs escaped while 11 000 were killed. If the lamp is strong enough for 99.99 per cent., it must surely be strong enough to kill the other .01 per cent. provided they were not shielded during the passage of the water through the tank.

The consumption of electric energy for sterilization by the ultra-violet rays depends greatly on the size of the apparatus. In the types like B2 or B5 it may vary from 0.4 to 2.0 kw. hours per 100 gal. The only really economical apparatus are those with the Pistol type lamps, which are themselves powerful light sources and which are so constructed that the light is all used in the sterilizing chamber. On physically good water in large plants, less than 100 kw. hours will be needed per million gallons. This would include a large safety coefficient, allowing for falling off in candle-power and other contingencies. It will always be good, anyway, to use a large overdose of the sterilizing agent if we want to produce a water which is at all times hygienically safe, and provided no disagreeable result is created thereby. You all know that with chemical sterilization we always have to use only just enough of the chemical if we do not want to spoil the water and make it unfit for consumption.

The mercury lamps have a property which makes us very sure of their action during their entire life. As soon as they are worn out they begin to extinguish themselves frequently. The operator is therefore warned that he has to replace such lamps. He has merely to attend to a proper regulation when the lamps are put in service, which is easily done by means of the regulating rheostats. It is easy to arrange automatic water cut-offs for the care of spontaneous failures of the electric light plant. In case the water is of varying physical quality a little practice will soon teach the operator when he has to put more or less lamps in service. A simple checking of the color of the water on the color scale gives sufficient indication of the number of lamps needed.

An important point we have to consider in studying the economy of this system is the possibility of filtering at much greater speed than we are doing nowadays, because it is possible to overdose

to any desired extent, when using the rays as a sterilizing agent, a thing which is impossible with chemical sterilization, which always requires a more thorough removal of the bacterial contents before the disinfectant is added.

The simplicity of this system of sterilization is striking and also its close resemblance to Nature's way of abiotic action, — that is to say, the bacteria-killing action of the rays of the sun.

DISCUSSION.

MR. JOHN C. WHITNEY. Mr. President, I should like to ask Dr. von Recklinghausen if there are any plants in operation on a large commercial scale.

DR. VON RECKLINGHAUSEN. The industry has only been recently introduced in this country, and up to the present date only one public water-supply plant is in operation, although negotiations are under way for the installation of some large plants.

As to European plants, I can mention the Luneville city plant, which has been running since 1912, delivering about two million gallons per day. Another very much larger plant was under construction at the beginning of the war for the city supply of Genoa. Besides this there have been municipal plants in service for several years at Saint-Malo, Maromme, Isle-sur-Sorgue, and in other places.

THE PRESIDENT. I noticed something in the paper which interested me very greatly, namely, that the American Hospital in Paris was employing this method for all of the water used in their hospital.

MR. JOHN C. WHITNEY. Mr. President, I would like to ask the doctor as to the probable cost of operation on a fairly large scale.

DR. VON RECKLINGHAUSEN. As I mentioned before, the cost of operating on a fairly large scale depends upon the quality of the water. In a particular case which is under discussion now, I doubt whether the current consumption will exceed 100 kw. hours per million gallons, and as the cost of the kw. hour in that place is about one tenth of a cent, the current bill would be about ten cents per million gallons.

The lamps will have to be repumped from time to time, and it may be that one or the other vital parts of the lamp will have to be replaced. The cost of this can only be estimated. I think that a figure of between ten and thirty cents per million gallons will be conservative. The moment I have some actual data on hand, with lamps manufactured in this country, I will publish the same for general use.

MR. TANNETT. Mr. President, I would like to ask the doctor what would be the probable action of ice in the sterilization.

DR. RECKLINGHAUSEN. We found there is no difference at all in the sterilizing action for water from about 50 degrees centigrade downward; there was no difference either between cold water and tepid water. When we came to ice, we found that the speed of sterilization in ice was about the same as in cold water, provided that the ice is clearly frozen — that is to say, not spongy; I mean provided that it is a real solid, glass-like looking piece of ice. Under those conditions sterilization goes on just the same, provided of course that the water does not contain any suspended matter.

PERSONAL CHARACTER IN ITS RELATION TO PRACTICAL EFFICIENCY.

BY CHARLES H. EGLEE.

[*Read March 10, 1915.*]

Mr. President and Gentlemen, — During the past twenty-five years that I have been here with you, and about the country, I have noticed a very great change, not only in the personnel of this assembly but in various other directions, and I want to talk to you a little about the changes in business methods; not that I am going to say anything that is new, — nothing of the sort; all of the things which I expect to say are trite and very well known to you.

I must refer to the President's statement that the papers, the technical discussions, and the publications of this Society are so well thought of everywhere. I find quotations from the papers of the New England Water Works Association wherever I go, and I find that the reports of its committees are held in very excellent standing in all sections of the country. I believe that this Association is doing a splendid work, not only in its own community but everywhere that its influence reaches.

Once in a while you depart from these technical discussions and introduce subjects of a more general character, and this subject of which I am asked to speak to-day is of that kind.

The subject is " Efficiency in Its Relation to Character," — the efficiency that is so much talked of at the present time. Everywhere the cry is " Efficiency " because business to-day, — general business, and of that I speak, — general business is in an extreme state of confusion. We are losing our old standards of measurement; we are losing our old ideals and endeavoring to set up new ones. Practices that were prevalent and proper twenty or thirty years ago are no longer considered so; many of them are very seriously condemned, and often they are very gravely punished. To change the standard of measurement in a whole nation from

the narrow classification of the welfare of business to the broad foundation of the welfare of the entire community, and to do that without creating ill-will among the people, and without distress or bitterness, is a task that is fitted for the highest intellects of the land. Business is becoming enlightened, and we are finding that it is no longer a personal matter. It is a service that must be rendered to the community, and the man who renders the greatest service is the man who receives the greatest returns.

I am very sorry that our political leaders of the present day have set up a slogan of competition, rather than to have set up the cry of coöperation. We are all trying to coöperate, and in consequence men are growing better in their business. Associations of this character, boards of trade and chambers of commerce, are drawing men closer together. The past generation has been an era of big things, and we were training men to do big things; but while we trained those men we lost the proper standard. I do not suppose that there is a man in business to-day who was in business twenty-five years ago, whose face is not flushed with shame when he thinks of the things to which his own chosen profession descended at that time.

Everybody to-day is talking about Personality and Individuality and Efficiency. A great deal of attention is being paid to what a man can produce, and how he can be induced to produce it. Experts are developing in this direction, which would have been impossible twenty-five years ago. An endeavor is being made to take advantage of the reserve force, which the late Prof. William James, of Harvard, demonstrated is latent in every man. This reserve force has been brought out in times of stress or necessity, and is what the athletes call a man's "second wind." Experiments have proven that, with proper rest and proper conservation of this energy, a man's daily production can be largely increased without fatigue.

Mr. Frank Taylor has taught a common laborer how to move forty-seven tons of material in a day with less effort than he formerly used in moving thirteen tons.

Mr. Frank Gilbreth has taught a bricklayer how to lay brick with five motions of his body, instead of eighteen, which was formerly the case.

Mr. Harrington Emerson has with the same machinery and the same force of labor built five locomotives in the same time that was formerly required in building three locomotives.

Everywhere is this cry of "Efficiency." You cannot take up a magazine and turn to the advertising pages, but what you see there are various schools of "efficiency," all of them appealing to you to take courses in them. The trade union started the improvement in the first place. The trade union set up a high ideal. It said, "If we can get as much wages as possible for as short a period of work as possible, we will have all the rest of the time for improvement." That was their cry. The ideal was all right, but there was difficulty in the leadership.

You cannot get a man to improve himself unless you give him an incentive for that improvement. Efficiency not only means the highest product of the individual, but it means at the same time the highest improvement and prosperity of the individual. Merely securing high wages and short hours does not improve the individual character; some other motive is necessary.

Then came the efficiency engineer, with his stop-watch and with his motion study, and he demonstrated how a man could eliminate a lot of waste motion. He is doing a fine work, but he has learned that it will not do that a man shall be treated merely as a machine; it will not do that he shall be shown merely how he can produce, without at the same time inducing in him that spirit of self-improvement and that motive whereby he shall improve his own character and increase his own prosperity at the same time that he increases the prosperity of the product.

So there is a third efficiency engineer now coming into the field, and that is the man that we call the "humanitarian" engineer. He cares for the welfare of his people, and he shows his people how they can improve themselves personally and in that way improve their product. There are a good many examples of that sort of efficiency in the vicinity of this city. I suppose the most prominent example in the country to-day is at Dayton, Ohio, in the National Cash Register Company. That Company has a wonderful man and a wonderful personality at its head. You find one near here also, in that great organizer whose name is almost lost or merged in the United Shoe Machinery Company,

— Mr. Winslow. They are doing a splendid work in that company, and its influence is steadily growing stronger. The humanitarian engineer is coming to the front, because his work means the improvement of the individual and the improvement of character and personality, as the work progresses.

There has never been any time, probably, when a man had as great an opportunity to advance himself and to advance the interests of his community, of his neighborhood, or the world about him, as he has at the present time. We are emerging from a state of confusion, and the men who will be prominent in establishing better methods are the young men of strong personality and good principles; men who are educated to impress their individuality upon the people that they come in contact with. And these young men find that they are meeting with a great deal better class of men than those who were doing business twenty-five years ago. Men that are stronger and more sympathetic; broader-minded and more honest. They have been obliged to be honest. They have not only practiced honesty as a policy, but the people who surrounded them have forced them to do so.

This great movement of which we are speaking is a movement of the whole people. It is an outward expression of the awakening of the conscience of the people. And this conscience is demanding honesty in high places; equality of justice without regard to station in life. It is demanding also an equal opportunity for all men to expand. This expression of the conscience of the mass of the people is forcing honesty along lines that were never thought of before.

No business to-day that is founded on fraud can last; it will surely collapse when the force of public opinion beats upon it. We are realizing that big swindling schemes, profitable as they were to a very few individuals, have been nothing less than waste when viewed from the standpoint of the state. We know that poverty, crime, disease, inefficiency, and illiteracy are also a public waste; and that the taking of large sums of money from the people in an illegal manner, for the purpose of creating a group of multi-millionaires, is no less a waste than is the waste of war. Men are better to-day, and we are finding an expression of that betterment in the laws that are being brought forward in all different directions.

All men are asking, "What are the qualifications that are necessary for a successful and efficient business man?" Those who have studied that question have come to the conclusion that there are two absolutely necessary qualities. There is nothing new in this statement; it is the thing that you all know yourselves. You know no man can be successful, unless he has these two qualities, the first of which is good health, and the second, good character — not to say that a man in poor health cannot achieve a good character, but that very few can. Our characters are dwarfed or warped by the limitations of our bodies, so that we cannot (or usually cannot) achieve sterling character in the face of poor health. The talk everywhere to-day is of good health. All sorts of systems are in operation for promoting good health. Health boards and various bacteriologists and sanitary experts are studying public health. But while we do this collectively, we neglect it individually. The rules of health are so simple that we forget about them. Every man can conserve the health that he has to-day. We may not be strong men, or athletes, but we can all use plain food, we can all exercise a little in the open air, and we can all get eight hours' sleep, and we can all cultivate a cheerful disposition. And with all these we can work hard. But late hours and gambling, the abuse of liquor and tobacco, low and debasing thoughts, and the society of some sorts of ladies, — all that sort of thing militates against good health and saps a man's energy. And energy to-day is what tells. There is no such thing as genius — genius is hard work. And the man who has got the best health is the man who is able to work hardest. There never was a time when the tennis court and the golf links, the gymnasiums and swimming pools were used as they are to-day, not only among young men but among the older men. I have a friend over sixty years of age who has just answered an advertisement in a magazine and is taking a course in home athletics. You know the system, — the one, two, three. It keeps his blood in circulation. He is over sixty years of age, and he says that he has benefited by the course so much in two weeks that he expects to live to be a hundred.

Good health is the foundation, the primary foundation, of a successful business career, — combined with good character. Two attributes of that are necessary also.

I suppose you think the first principle is honesty, but that is not so. Very often you will see a rogue successful where an honest man fails. The very first thing that a man must have is courage. Not the courage of a soldier, who in a moment of enthusiasm or in company of his fellows undertakes a hazardous enterprise; nor the courage that makes a man a hero in a critical situation or in a fight. That is not the courage that we are talking about. The greatest courage is that which takes up the little daily petty difficulties; the droppings that wear away the rock; the strain upon your nervous energy; the work you do for which you are not paid; the incompetence and the inefficiency of your employees; the pride and the arrogance and the overbearing manner of your employer. All these things are working against your courage the whole time. The man who faces these with resolution, or who overcomes them with a determined purpose, is going to succeed just simply by the force of his daily courage.

The courage that is thus trained, every single day, is not overcome by those earthquakes, those crises, those tremendous convulsions that always occur in every business life. Almost all the men who are listening to me now know what that is. You have all been up against it, and you know that if you had not had that courage, trained by the little petty annoyances of daily life, you never could have gone through with the big things.

Courage is a quality that grows upon us every day as we practice it; it is the greatest attribute that we can possess; it is the foundation of a successful business career.

With that sort of courage we must combine the element of faith. With these two, we overcome almost everything.

By faith, I mean, in the first place, faith in the proposition in which we are engaged. There is no use going into any sort of a proposition unless we have faith in it. Then we need faith in the people we are connected with in that proposition, and faith in ourselves. There is such a thing as conceit and overweaning egotism, which is very objectionable; but a quiet self-confidence,— a faith that we are able to achieve, a faith that we are able to go forward, a personal faith in ourselves,— that what man has done man can do, and we are just as good a man as another — if we go forth with that faith in ourselves, our courage will overcome every obstacle.

Then there is another kind of faith, and that is faith toward the people that we are associated with, and faith in our fellow-men. That is growing in the business life of to-day. It is a splendid thing to cultivate, for it makes us feel good, and if we feel good we can work hard. We ought to have this faith in the other fellow, believing that he is doing as well as he knows how. He may not be doing it just exactly our way; in fact, he may have a better way. We have no standard for judging him, and so we ought to have a good deal of faith in him.

With these two qualities at the foundation, there are other traits of character that emanate from them. And the first is loyalty. I should like to talk a lot about loyalty. We need loyalty to the proposition, loyalty to the house. We ought to get that right down to the foundation of our system in the first place, and then believe that the people associated with us are also loyal, and are working together in coöperation. So many men think that if they work hard and earn their salary this is all that is expected of them, and if there is any excuse for it they are forever criticizing their orders, kicking about the management, and sowing seeds of discontent wherever they can. This is not an example of loyalty, but it is the worst sort of disloyalty, and employees that are doing that sort of thing, just as sure as they are born, are getting themselves ready for the toboggan. But why shouldn't they? Almost every employer is complaining about the disloyalty of his employees. Where is the employer that is loyal to his helpers? When you are directing other men, are you showing them an example of loyalty? Do you believe in them? Do you believe that they are doing the best that they are capable of to-day? Do you believe in the boys? Are you showing them how to be loyal to you? When your bookkeeper at the end of the month hands you the usual statement and you look at it and see three or four errors, the first thing, what do you do? Scold, curse, and complain? Do you stop to think that the man may have been sitting up all night with a sick wife? Do you care whether he has any wife or not? How loyal are you to that employee who is working for you and for the interests of the firm the best he knows how? He isn't as good as you are,—if he were he would be in your position and you perhaps would be working for him.

I was buying an overcoat, the other day. It was a large salesroom, with thirty or forty salesmen on the floor, and I was talking with the salesman that I had dealt with for several years and who thinks a good deal about efficiency. He writes sometimes for the papers about efficiency. I said to him, as I looked over the floor: "If all these men here were only loyal, if they were only coöperating, if they were only strong for the firm, instead of coming down here every morning and kicking and growling!" "Why," he said, "how did you happen to put your finger on the very worst feature of this whole establishment?" "My dear sir, simply because it is the worst feature of every establishment." "Why," he said, "these fellows on this floor are the worst sort of kickers, the worst sort of growlers!" And I said to him: "What are you doing? Are you one of the same sort? Are you talking the same way? Here you are telling me the worst feature of your establishment, and I am a stranger. What are you doing to change all this?"

We think a great deal about this quality of loyalty, mostly in criticism of others, but when we think about it again, let us also think: "What am I doing myself? What is my individual attitude?"

Now, of course if a man has all these traits he has got to be honest, not only in money matters, or not particularly in money matters — the law will take care of that. He must be honest in other directions also. Are we honestly doing our work, and are we honestly seeing that those for whom we are responsible honestly do theirs? We are not. I do not suppose that there is any man, any average man, who honestly strives every day to rank high in the scale of efficiency and honestly give out to the world the very best that is in him. No. We are usually too lazy! We are working up to the day of the pay envelope. We are working just so that we get by.

I was in the office of the manager of a big department store here in Boston, the other day, — a man whose day is crowded every minute; and he has over his desk a big motto which says, "How lazy do you dare to be?" That is the great trouble with most of us, — to be honest with ourselves. The man who learns how to be honest to himself cannot help but be honest to other people.

Now, suppose we have all this courage and faith and persistency and loyalty, and all the rest of it. The question is: Do we make money? Not necessarily, gentlemen! Money is not made by the exercise of any of these qualities. Money is made by the exercise of the supreme quality, — originality; or what the efficiency expert is calling to-day "initiative." Initiative is doing the thing without being told. It is finding a short cut to the result. It is instituting an economy that is new. It is discovering something that no one has discovered before. It is being first in any movement. "Initiative" — that is the great money-making quality. And if a man has this quality and combines with it the faculty of managing men, that man is bound to make money. It doesn't matter whether he is an honest man or a rogue. But he makes money more easily if he combines with initiative these other good qualities. If we have initiative to the highest extent we are at the head of the Steel Trust. If we haven't it to quite so great an extent, we are at the head of some other enterprise.

So, if we are going to be successful, — and I am not speaking only to the active members of the New England Water Works Association, but to the salesmen that meet here, — if we are going to be successful in the world, we cannot enter into business in any haphazard sort of way. We must study ourselves, our habits, and our disposition, and endeavor to get into some sort of work where we can expand along natural lines. That is very difficult, — the fitting the right man to the right place. There is no system at the present time here to do this. In Germany they have perfected efficiency to such an extent that they claim there are only two per cent. of men who are in the list of the absolutely inefficient, and here in this country we have eighteen per cent. constantly no good, — commercial defectives; eighteen per cent. in this country, and they have ciphered it down in Germany to only two per cent., simply because we have no method. Many a man is in Wall Street who ought to be a farmer, and many a man is an engineer who is a very poor engineer but who would make an excellent lawyer. We have our world full of round pegs trying to fit square holes. And what are we doing about it? We are beginning to think about it.

Dr. Blackford is trying a system at the Sturtevant Blower

Works. A system for testing the temperament and qualifications of applicants for work, whereby it may be discovered whether a man is fitted to any certain position. It is not to be absolutely relied upon, but is a long way in advance of any other method. It is a beginning along these lines. How are we going to fit that man to the job? That is what the efficiency engineer is trying to do to-day. He must, in the first place, improve himself. He must educate himself and then educate other men so that these may bring along the men who are not educated, that this tremendous waste of human material shall be done away with. The day may come when we will no longer have eighteen per cent. of business defectives in this country. Perhaps we may even be some day as good as the Germans.

We advance by studying ourselves. The greatest American that ever lived understood this. I refer to Benjamin Franklin. He studied himself all through his life. He kept a little memorandum book and he wrote down every day an analysis of his time and what he did with it. He would take a whole month to eliminate a particular fault in his character. He would study that one fault until he had eradicated it. Then he would take another month to train himself in some good quality that he had observed in somebody else. All his life he did that. And see what tremendous results he achieved from the initiative latent within him; he didn't know he had it. It is latent in every one of us, and we never know it until we begin this self study. It is the province and the benefit of the efficiency engineer, that he is waking us all up individually, and the work is simple if we can get away from that depressing laziness. Every man can train himself, and the results of that personal study one day are going to be manifest. They not only elevate him, they elevate everyone he comes in contact with.

We know that this nation can make no advance whatever except the units — we units — advance as individuals. When we put into the background honor and integrity, and bring forward nothing but the game of grab and the principle of every man for himself, we are not going forward, we are distinctly going backward; and as we go back, we hold back the advancement of the civilization of this entire nation. When we neglect our individual

responsibility as a citizen, when we no longer attend the caucus, when we let somebody else go to the polling booth in our place, we are holding back the advancement of our community because we do away with our individual responsibility as a citizen. And so we do as a business man in exactly the same way.

The efficiency engineer is improving this. The best thing that he seems to have done at the present time is to have eliminated waste motion. In that he has done a very valuable work, for the value of time has never been considered in a scientific manner before. Everybody thinks he works hard, and that he must spend a certain amount of time to rest from fatigue. You go home at night and say you have put in such a hard day's work, when you haven't really done any such thing; you will find if you analyse your day that perhaps one half of the time has been wasted in foolish and erratic movements. Put a fly in a bottle and he will tire himself out, but what will he accomplish? And that is the way a great many of us do, because we have never trained ourselves with a scientific mind to observe the conditions of our own individual career. We would rather tell somebody else what to do than try and practice that very same thing in our own business and in our own phase of life. I cannot impress too strongly this question of laziness.

We are all trying to make money, trying to make it too fast. Is it the greatest consideration in life? I suppose it isn't the first consideration in life, but it is a very happy state of mind to be in, —that making of money. We are all working for it, but I do not believe that we are working merely to make money. We are working for peace of mind. It isn't the acquisition of money or power or knowledge or place, that is the end we seek, it is the peace. And we are saving up for our old age so that we shall at that time be at peace. But there is no peace, and there never will be any peace, until every man understands his absolute individual responsibility for his own life, and trains himself, — at least trains himself as carefully as he is trying to train his little six-year-old boy. And he cannot train himself any better than in this game of business, — I do not care in what branch he is engaged. For the game of business is a very great game. It is a wonderful game. There is more fun in it, there is more pure joy in it, there is more

development in it, than in any game that a man can play. At any rate, we spend more than half of our time in it, and if we cannot get joy in life out of our business where in the world can we get it? It is the joy of creation, it is the joy of doing something with our own hands, — just like that little six-year-old boy who takes his saw and his hammer and his little tools and brings you something that he has made himself.

The creative instinct is the foundation of the race, it is the ineradicable instinct, — reproduction, and from that production. We love to produce, we love to build, we love to make things with our own hands. And we do that in our business.

We cannot make a success in it unless we work hard. It takes a good many years of study to learn how to do any one thing well; and no substitute for hard work has been found in a great many thousand years — not one. But, if you know when and where and how to place reliance upon a man, you are a genius. If you can supervise and regulate and delegate and keep discipline out of sight, you are a wonder. If you can take a tabulated statement at the end of the month and let it show the result of your department, and keep your hands off the details, you are a great man. And more than that, if you can take a force of uneducated, unregulated, undisciplined men, and train them to do the work that you want done, and keep them good-natured on small pay, why, you are the man to whom we take off our hat. You learn that in business. You learn it first by the development of your own character, and you learn it by study — whether you know it or not — you learn it by the study of these great principles, — courage and faith, loyalty, persistency and honesty. And that, with your "initiative," gentlemen, places you in the enviable positions that you now occupy.

PROCEEDINGS.

HOTEL BRUNSWICK,
BOSTON, MASS., March 10, 1915.

President Leonard Metcalf in the chair.

The following members and guests were present:

HONORARY MEMBERS.

Albert S. Glover, Frank E. Hall.

MEMBERS.

R. C. Allen, J. M. Anderson, C. L. Baker, L. M. Bancroft, G. W. Batchelder, A. E. Blackmer, C. A. Bogardus, George Bowers, E. C. Brooks, James Burnie, J. M. Caird, G. A. Carpenter, George Cassell, J. C. Chase, H. S. Clark, H. W. Clark, J. E. Conley, J. H. Cook, C. E. Davis, J. M. Diven, John Doyle, E. R. Dyer, H. P. Eddy, C. H. Eglee, E. D. Eldredge, F. F. Forbes, S. F. Ferguson, Patrick Gear, J. W. Graham, H. J. Goodale, R. K. Hale, F. E. Hall, J. O. Hall, A. R. Hathaway, D. A. Heffernan, D. J. Higgins, J. L. Howard, A. C. Howes, W. S. Johnson, J. W. Kay, E. W. Kent, Willard Kent, S. E. Killam, C. F. Knowlton, W. T. Lenehan, F. A. McInnes, Thomas McKenzie, J. N. McKernan, Hugh McLean, A. E. Martin, W. H. McMahon, W. E. Maybury, John Mayo, F. E. Merrill, G. F. Merrill, Leonard Metcalf, H. A. Miller, William Naylor, F. L. Northrop, T. A. Peirce, H. E. Perry, J. J. Prindiville, L. C. Robinson, B. M. Rockwood, C. M. Saville, A. L. Sawyer, C. W. Sherman, E. C. Sherman, G. H. Snell, G. A. Stacy, G. T. Staples, W. F. Sullivan, H. A. Symonds, L. D. Thorpe, A. H. Tillson, E. J. Titcomb, W. H. Vaughn, Percy Warren, R. S. Weston, W. J. Wetherbee, G. C. Whipple, G. E. Winslow, I. S. Wood, Eugene Carpenter, H. B. Andrews, Carleton Scott, W. J. Turnbull. — 87.

ASSOCIATES.

Builders Iron Foundry, by F. N. Connet and A. B. Coulters; Chapman Valve Mfg. Co., by J. J. Hartigan; Darling Pump & Mfg. Co., Ltd., by H. A. Snyder; *Engineering Record*, by I. S. Holbrook; A. M. Byers Co., by H. F. Fiske; Hayes Machinery Company, by F. H. Hayes; Hersey Mfg. Co., by A. S. Glover and W. A. Hersey; Lead Lined Iron Pipe Co., by T. W. Dwyer; Ludlow Valve Mfg. Co., by A. R. Taylor; H. Mueller Mfg. Co., by G. A. Caldwell; National Meter Co., by J. G. Lufkin and H. L. Weston; Neptune Meter Co.,

by H. H. Kinsey; Norwood Engineering Co., by H. W. Hosford; Pittsburgh Meter Company, by V. E. Arnold and J. W. Turner; Macbee Cement Lined Pipe Co., by J. D. MacBride; Rensselaer Valve Co., by C. L. Brown; A. P. Smith Mfg. Co., by F. L. Northrop; Standard Cast Iron Pipe & Foundry Co., by W. F. Woodburn; Thomson Meter Co., by E. M. Shedd; Union Water Meter Co., by E. K. Otis and F. E. Hall; Water Works Equipment Co., by W. H. VanWinkle; R. D. Wood & Co., by H. M. Simmons; Henry R. Worthington, by Samuel Harrison. — 28.

GUESTS.

Joseph E. Perry, Portland, Me.; H. E. Reynolds, Barre, Vt.; John Kelley, water commissioner, Braintree; F. M. Bates, DeWitt C. Webb, Boston; G. A. Stowers, Billerica; Joseph Weeks and E. A. MacMaster, Bridgewater; Herbert F. Conant, Attleboro; John H. Woods, S. J. Wright, and Dr. W. J. Powers, Holyoke; Mr. Mahoney and Mr. Newsholme, Methuen; John J. Pearson, Middleboro; Dr. Edward Bartlett, George H. Leland, Providence, R. I.; George W. Woodward, Westerly, R. I.; M. L. Miller, Springfield; Mr. Cullen, Woonsocket, R. I.; Mr. Maynard, Mr. F. W. Tucker. — 22.

THE PRESIDENT. Before beginning the exercises of the afternoon, I want to say just a brief word to you in recognition of what you have done for me, gentlemen. For I count it one of the greatest honors that has ever come to me, that of being elected President of this Association.

I think that all of you would have been very much pleased if you could have heard some of the opinions that I have heard expressed during the past two years, in the Far West, in regard to the work of this Association. Its work is as well known on the Pacific coast as it is on the Eastern coast. Many men have I heard say: "We fear that we can never attend a meeting of the New England Water Works Association, but we value greatly the publications which it has issued." They recognize the worth of those publications, the work of your committees, the record which the Association has made for itself.

I can only say to you that, so far as I personally am concerned, I shall do the best that lies in me to further the interests of the Association, relying upon your good help in such ways as you can assist me — and there are many ways in which you can assist me — in furthering the interests of the society this year.

As I look around me, I realize what a real fund of information

there is stored in the heads of the various men seated about these tables. I feel that I am very much in the position of a judge of whom the story was told in California, not long ago, who was hearing a case against some Chinamen that had been brought before him. They were honorable citizens; they had gotten into some difficulty, — I don't know just what, — but the judge, feeling that he couldn't get information from them except through an interpreter, had to call to his aid such a man. The situation became more and more difficult. He knew favorably one of the men who was testifying before him, but he felt that he wasn't getting at the root of the matter. Finally he turned to the interpreter and asked him to ask his friend what he could do to get the Chinamen to tell the whole truth, to tell what they knew, and what the matter was with the way in which he was conducting the trial. The instant reply was that they didn't respect Uncle Sam's oath, and they hadn't been sworn in the proper way. So he said: "Very well, we will swear them in the proper way. What should we do?" The interpreter told the judge what to do, and, followed by the Chinamen, he started out into the back yard, where a rooster was caught and its head cut off, and the Chinamen had to take an oath as the blood dripped from the neck of the headless rooster. This was done with the utmost ceremony. The procession filed back again into the court room, and the proceedings went on, but again the judge was conscious that he was getting no nearer the truth than he had under the former conditions. He was very much disgusted, but he had to give up his efforts. After the trial was over and the men had been acquitted, the judge said to his friend: "John, what was the matter; why didn't the China boys tell the truth after we had sworn them in that way?" The man's instant reply was: "The trouble is, your lordship, you no cut 'em off head de light way!" [*Laughter.*]

Now, it remains to be seen whether I can succeed in getting your assistance by cutting off your heads the right way, or at least by tapping the fund of information that lies in them.

The Secretary presented applications for membership, duly recommended and endorsed, from John Cullen, Woonsocket, R. I., foreman of the Woonsocket Water Works for thirty years;

Calvin L. Baker, Abington, Mass., superintendent of Abington Water Works.

On motion of Mr. Frank L. Pierce, the Secretary was directed to cast one ballot in favor of the admission of the applicants, and he having done so they were declared duly elected members of the Association.

THE PRESIDENT. I will make one announcement on the suggested committee upon "Service Pipe." I will appoint Mr. William S. Johnson, Mr. Harry W. Clark, Mr. George A. Stacy, Mr. William F. Sullivan, and Mr. A. E. Martin.

It has been suggested that, as amplifying the work of the committee which has recently reported upon "Meter Rates," it would be wise for the Association to appoint a committee, or to continue the work of the committee along the line of making an investigation of the water unaccounted for or lost in leakage; that that question also is involved in the meter rates, and that it would be desirable to secure more data, more exact information, than we have upon it.

Do you care to give consideration to that matter? I may add that the Executive Committee thought that it would be of advantage to make such an investigation. Does any one care to make a motion in regard to the matter?

MR. GEORGE A. STACY. Mr. President, I believe it is important that the committee continue that investigation as you suggest. I think accounting for the water is a vital principle, and that this is a proper problem to solve. If the Association continues this matter it will be doing a good work.

THE PRESIDENT. It is moved and seconded that the committee which reported upon "Meter Rates" be asked to continue and to extend this work to the extent of making investigation concerning water lost in leakage, by non-registration of meters or otherwise.

The President put the motion, and declared it unanimously adopted.

THE PRESIDENT. I will make announcement that the Executive Committee took up again this morning the question of place for holding the next convention, in response to some difference of opinion which had been urged upon this question. After careful

consideration and discussion, the board voted to rescind its previous action, and New York City was selected as the place for the holding of the next convention.

Is there any other business to come before the meeting?

MR. WILLIAM F. SULLIVAN. Mr. President, there is one matter that we took up at the last meeting, in regard to an invitation to the members of the American Water Works Association to join with us.

THE PRESIDENT. As announced upon the circular, the question was discussed by the Executive Committee at the February meeting, and it was then voted "that initiation fees be remitted to members and associates of the American Water Works Association applying for admission to the New England Water Works Association during the year 1915." In order that the membership at large might have an opportunity to express its opinion as to the desirability of this, the Executive Committee has caused notice to be made of it upon this circular. The floor is now open for discussion or for comment.

MR. CHARLES W. SHERMAN. I don't know, Mr. President, that there is need to say very much on this matter. Probably most of us know that for more than a year past the American Water Works Association has extended the courtesy of admission to its membership to members of this Association without paying an initiation fee, and it is no more than fair that we should do the same thing for them. The associations, while rivals to some extent, are supplementing each other's work to a considerable degree, and a large portion of the members of each Association could with great advantage be members of both. With that in view, the Executive Committee at the February meeting passed this vote, under which, if approved by the Association, the members of the American Water Works Association when elected to membership in this Association can become members without paying an entrance fee. But we felt that this step was so different from anything that had been done heretofore that we did not care to put it into effect without submitting it to the Association for approval, with notice of that proposed action going on the circular.

In order that the matter may be discussed and the opinion of

the meeting arrived at, I will move that the action of the Executive Committee in passing this vote be approved by the meeting.

MR. CHARLES H. EGLEE seconded the motion.

MR. WILLIAM F. SULLIVAN. Mr. President, should this not be an amendment of our By-Laws?

THE PRESIDENT. I think not, sir. At least I would so rule. Is it your view that it is in conflict with the By-Laws?

MR. SULLIVAN. Yes, Mr. President, that is my view. But I am not sure of it. We have got the By-Laws here.

THE PRESIDENT. To which by-law did you refer, Mr. Sullivan?

MR. SULLIVAN. The section in regard to "Dues."

THE PRESIDENT. Well, but does that prevent the Association from abating the dues for a certain limited period?

MR. SULLIVAN. At the February meeting this came up before the Executive Committee. The Executive Committee discussed it, and in looking over the By-Laws at that time I was given the impression that this was a matter of amendment to the By-Laws. And that is why this written notice was given to the members here to-day, as the By-Laws provide that on any proposed change of by-laws such notice shall be sent to the members.

THE PRESIDENT. Oh, you mean the occasion for putting it in the circular?

MR. SULLIVAN. No, in order to be able to remit dues, to admit members without paying the initiation fees, you have to change your By-Laws.

MR. MERRILL. Mr. President, under Article III of the By-Laws, the last part of Section 1, it states: "All applications for membership presented to the Association for action must be accompanied by the proper initiation fee and dues for whole or fractional part of current year in which application is presented." So that this action will necessitate an amendment, I should think.

MR. SHERMAN. Mr. President, I examined the Constitution pretty carefully in view of this action, and while I do not pretend to be a constitutional lawyer, I could not see anything that would prevent the Association from abating any fees or dues that they might see fit to abate.

MR. SULLIVAN. I think so, too, Mr. President, but the im-

pression I obtained at the Executive Committee meeting was that it was an amendment of the By-Laws, and that is why we notified the members in writing.

THE PRESIDENT. I would say to the members that I read these sections over, and it had not seemed to me personally that there was anything in them which would prevent the Association, after due action of the Executive Committee and due notification, which has now been had, from taking any such action. You are not doing away with the custom of charging an entrance fee; you are merely abating it to a certain class for certain good reasons, which the membership it seems to me has a perfect right to determine. The Chair would so rule, unless there is opposition and you wish to have that question put.

MR. J. M. DIVEN. Mr. President, does the Constitution defining the duties of the Executive Committee give them that power? I haven't a copy of the Constitution with me.

THE PRESIDENT. In answer to that, Mr. Diven, I would say that it seemed to us that it does give them that power.

MR. DIVEN. Mr. President, what is a little thing like the Constitution between friends? [*Laughter.*] Every water-works man in the country ought to be a member of both Associations. I think that at the present time there are about three hundred interlocking members, but that interlocking membership ought to apply to the entire membership of both the Water Works Associations in the country. There is no water-works man in the country who can afford not to be a member of both Associations and have their reports in his library.

The President put the motion for the amendment and it was unanimously adopted.

The first topic for the afternoon was the Discussion of the Report of Committee on Filter Statistics, Prof. George C. Whipple, chairman. The discussion was opened by Mr. William S. Johnson, consulting engineer, Boston, who also made a motion, which was seconded by Mr. Eglee and unanimously adopted, that the last recommendation of the committee (that it be continued for another year) be carried out, and the existence of the Committee on Statistics of Water Purification was accordingly extended for another year. The following named gentlemen also participated

in the discussion of this report: James M. Caird, Carleton E. Davis, and Harry W. Clark.

"Personal Character in Its Relation to Practical Efficiency" was the subject of an address by Mr. Charles H. Eglee, of the Aberthaw Construction Company, Boston.

MR. FRANCIS W. DEAN. Mr. President, I think we ought to present a vote of thanks to Mr. Eglee for this talk, for I am free to say that it is the best talk of the kind that I have ever heard in my whole life. I move, therefore, that we give him a vote of thanks.

THE PRESIDENT. It is moved and seconded that a vote of thanks be given to Mr. Eglee for his exceedingly interesting talk.

The motion was unanimously adopted.

MR. EGLEE. I thank you, gentlemen. I thank you because it comes from men, as I said before, whom I have been associated with and intimate with and grown up among for the past twenty-five years, or more, perhaps.

THE PRESIDENT. I am sure every man here feels that while the subject which Mr. Eglee has treated is old as the sun, and the subject is trite, perhaps, yet he has clothed it in a most interesting way. He speaks with the authority of a man who has himself achieved results.

The Topical Discussion upon "Concrete Standpipes" was opened by the President, and Mr. Thomas McKenzie, engineer of Westerly Water Works, followed with a paper illustrated with slides. Mr. Herbert F. Conant, of Attleboro, followed with a paper descriptive of the repairs to the Attleboro standpipe. Others who took part in the discussion were Mr. H. B. Andrews; Mr. Frank A. Marston, who showed slides of various standpipes; Mr. Bertram Brewer, Mr. Raymond C. Allen, Mr. Francis W. Dean, Mr. William S. Johnson, and Mr. Simpson of Simpson Bros.

The President announced that he had received one or two letters and papers, including one from Mr. D. C. Webb, civil engineer of the navy, but that in view of the lateness of the hour they would be published in the columns of the JOURNAL instead of being read at that time.

EXECUTIVE COMMITTEE.

Meeting of Executive Committee of the New England Water Works Association at headquarters, Tremont Temple, Boston, Wednesday, March 10, 1915.

Present, President Leonard Metcalf, members Carleton E. Davis, George F. Merrill, Caleb M. Saville, Charles W. Sherman, William F. Sullivan, Edwin C. Brooks, Samuel E. Killam, George W. Batchelder, Willard Kent, Richard K. Hale, Lewis M. Bancroft, and Past President Frank A. McInnes.

Applications for membership were received from Calvin L. Baker, superintendent water works, Abington, Mass., and John Cullen, foreman water works, Woonsocket, R. I., and were, by unanimous vote, recommended therefor.

A communication with reference to lecture on waterproofing was referred to the President, with power to act.

A general discussion of the subject of place for holding next annual convention was had, after which it was voted to rescind the vote "that the next annual convention be held at the White Mountains," passed at a special meeting of the Executive Committee held December 26, 1914.

On motion of Mr. Batchelder, seconded by Mr. Merrill, it was voted "that the next annual convention of the New England Water Works Association be held in New York City."

The President was, by vote, authorized to appoint a committee on increased membership and a committee on June meeting.

Adjourned.

WILLARD KENT, *Secretary.*

Meeting of the Executive Committee of the New England Water Works Association at headquarters, Tremont Temple, Boston, Mass., May 7, 1915, pursuant to call of the President.

Present: William F. Sullivan, Caleb M. Saville, Charles W.

Sherman, Edwin C. Brooks, Samuel E. Killam, George W. Batchelder, Willard Kent, Richard K. Hale, Lewis M. Bancroft, George A. King, Frank A. Barbour, and F. A. McInnes.

Messrs. McInnes, Sherman, and Barbour, the committee appointed December 26, 1914, to consider the question of raising funds for future conventions, reported the following recommendations, viz.:

1. The general arrangements for the Convention, including hotel arrangements, program of papers, and program of entertainments, shall be in the hands of an Entertainment Committee, to be appointed by the President.

2. The exhibits by Associates shall be in charge of a Committee on Exhibits, the chairman and a majority of the members of which shall be representatives of Associates of the New England Water Works Association. This committee shall have full charge of all arrangements for exhibits, with authority to assess the exhibition cost among the exhibitors.

3. The fund offered for the entertainment of the Convention (being exclusive of the Convention exhibit costs) by the Water Works Manufacturers' Association shall be turned over to the Entertainment Committee, which shall neither ask nor accept any further contribution from any member of the Water Works Manufacturers' Association. It may, however, solicit contributions from Associates of the New England Water Works Association who are not members of the Manufacturers' Association, and from other individuals not connected with the latter Association. The administration of this entertainment fund shall be in the hands of the Entertainment Committee, which shall return to the contributors, pro rata, any funds remaining after the Convention bills have been paid, and shall render a report of its doings, receipts, and expenditures, to the Executive Committee of the New England Water Works Association.

4. The right of Associates of the New England Water Works Association to have a representative at all meetings of the Association, as permitted by the Constitution, is hereby determined to be limited to a single representative in the case of the Annual Convention, and such representative may introduce a single guest. Associates desiring to be represented by additional representatives

at the Convention may do so on the payment of $5 for each additional representative, each such payment to carry the privilege of introducing one guest. All moneys received from such payments for additional representatives shall be turned over to the Committee on Exhibits and used in defraying the necessary expenses of that committee.

After discussion, on motion of Mr. Bancroft, seconded by Mr. Brooks, it was *voted*, that the recommendations be adopted for the convention of the Association of the year 1915.

The President is by vote made a member of the Committee of Arrangements, with power to appoint proxy.

Adjourned.

Attest:

WILLARD KENT, *Secretary.*

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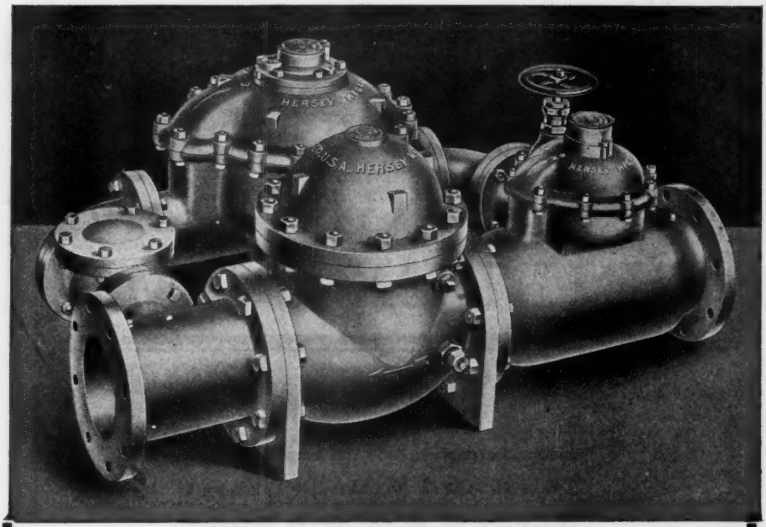

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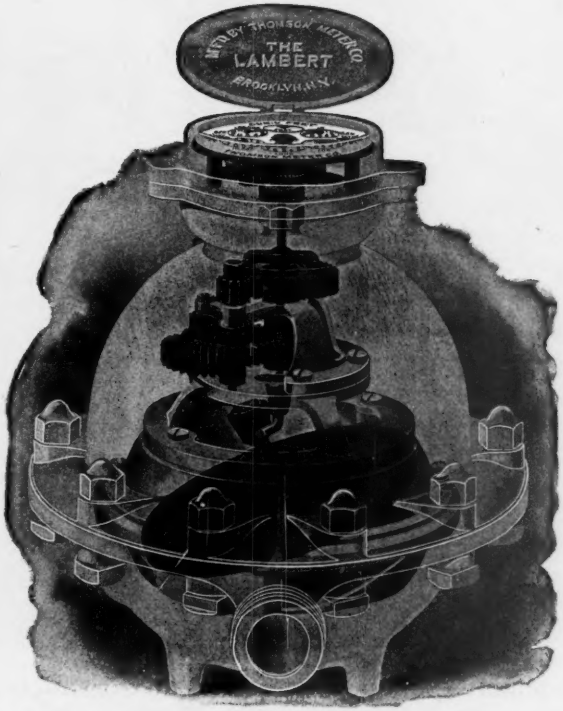

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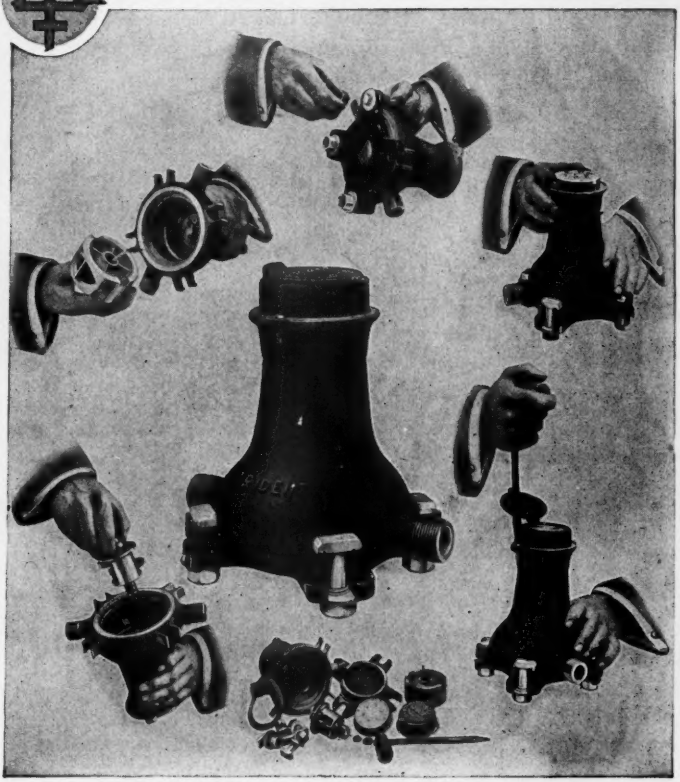

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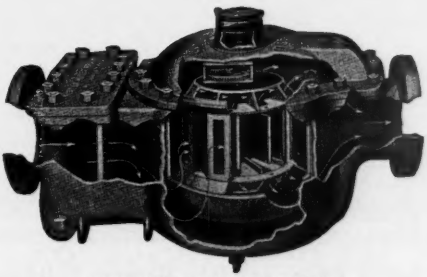

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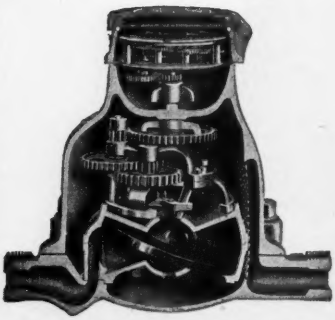

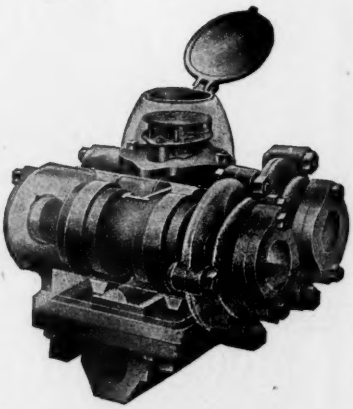

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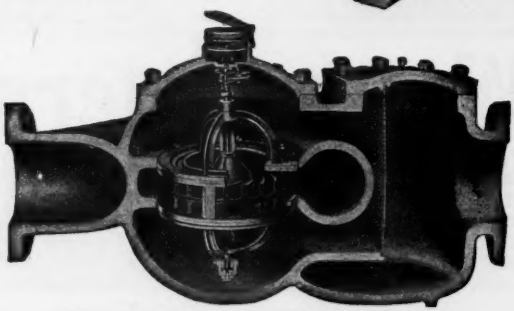

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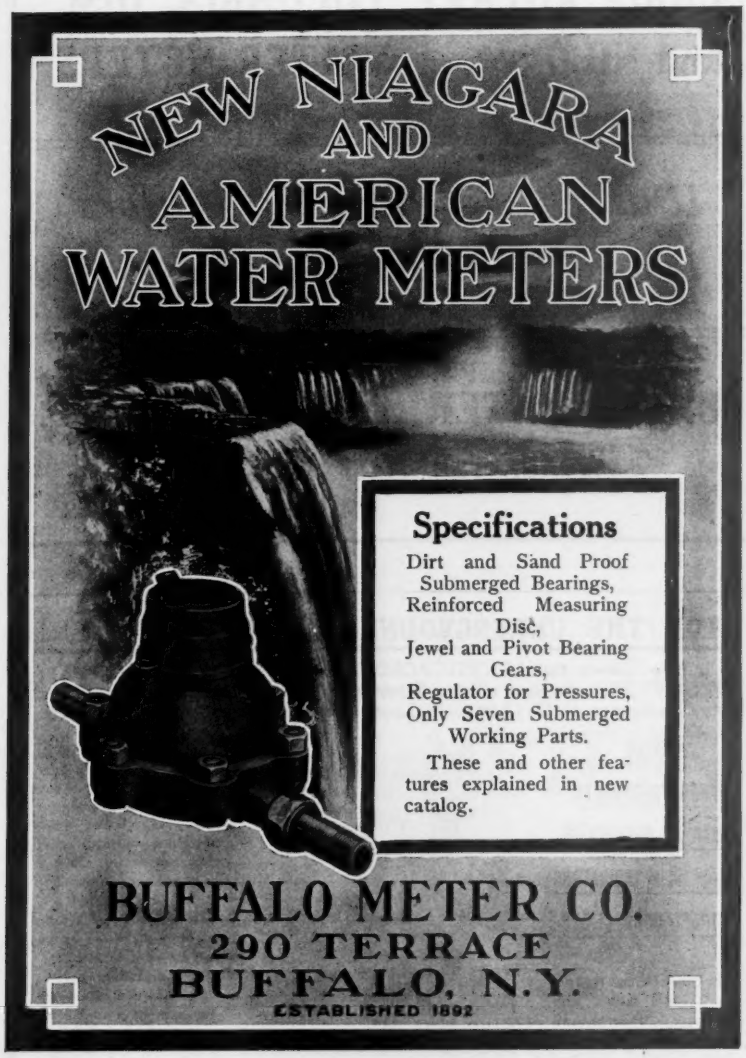

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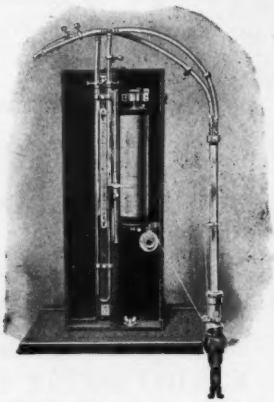

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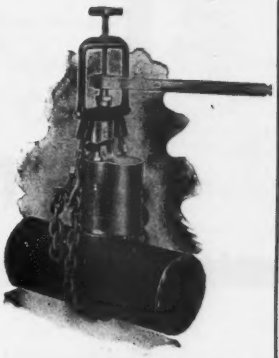

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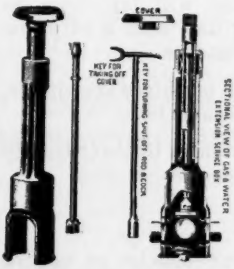

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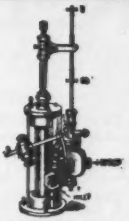

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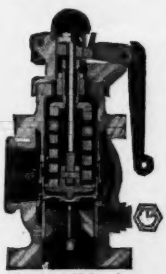

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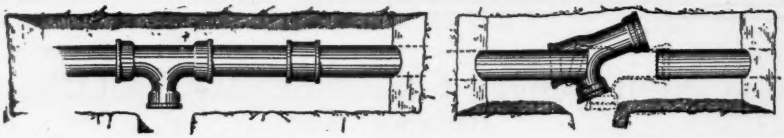

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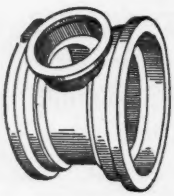

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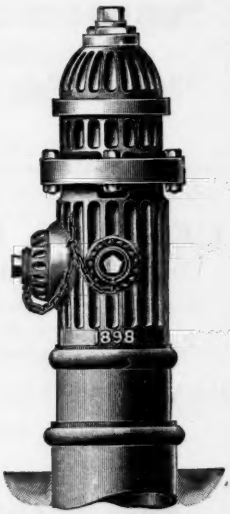

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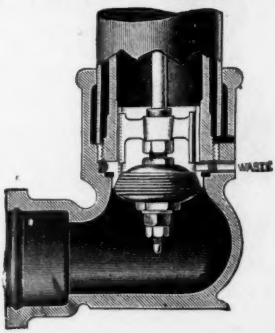

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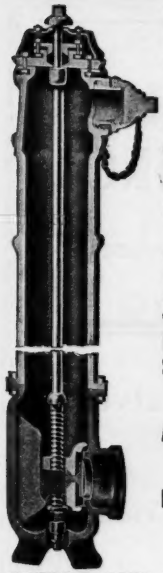

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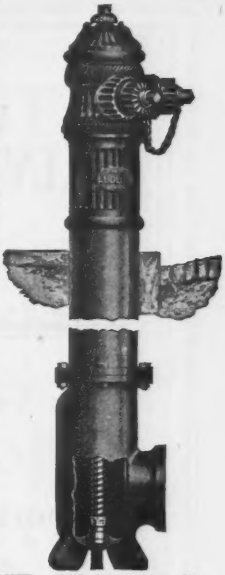

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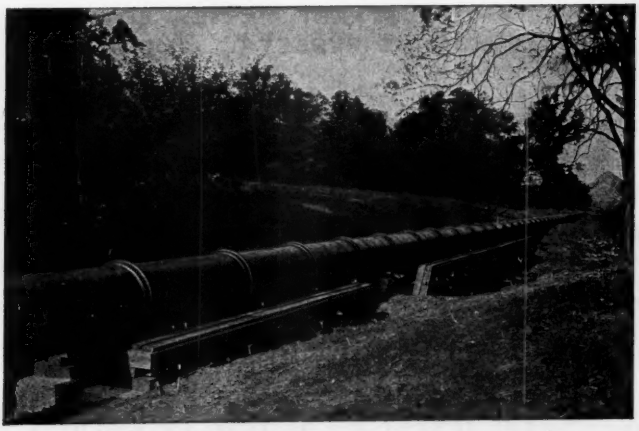

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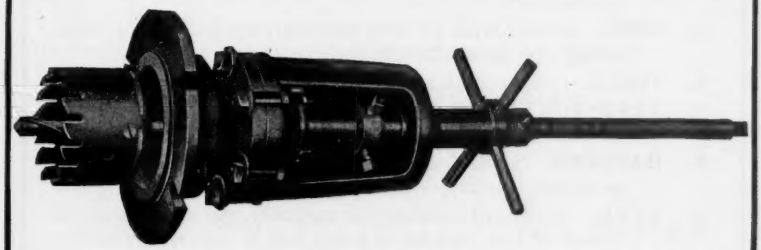

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